PUBLISHED EVERY SATURDAY BY

THE W. J. JOHNSTON COMPANY, Limited,

167-176 TIMES BUILDING, NEW YORK.

Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, 28 Hathaway Building, Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION, IN ADVANCE, ONE YEAR $3.

(Including Postage in the U. S., Canada or Mexico.)

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VOL. XIX. NEW YORK, JUNE 18, 1892. NO. 25.

CONTENTS.

EDITORIAL: PAGE.

Paragraphs ... 409

ILLUSTRATED ARTICLES:

Electric Pipe Bending ... 411
Test of the Neversink Mountain Electric Road.—IV., by Hermann S. Hering and Wm. S. Aldrich ... 412
Power Required to Haul Suburban Passenger Trains ... 414
A New System of Electric Propulsion, by H. Ward Leonard ... 416
Long Distance Transmission for Lighting and Power, by C. F. Scott ... 419
Series Electric Traction, by N. W. Perry ... 421
A New Flush Switch ... 423
A New Die Slotter ... 423
The Little Diamond Fan Motor ... 424
Railway Current Controller ... 424
A Two-Wire Cleat ... 424
The Senior Sight Feed Lubricator ... 424
A New Lightning Arrester ... 424

MISCELLANEOUS:

The Chicago Meeting of the American Institute of Electrical Engineers ... 410
The Efficiency of Steam Locomotives at High Speeds ... 410
Obituary ... 410
Gas Engines for Dynamo Driving ... 410
Utilization of Smoke ... 411
Electricity in the Belt Line Tunnel ... 412
The Best Frequency for Alternating Currents ... 413
Coming Developments of Electric Railways, by Frank J. Sprague ... 415
Electrical Engineering at the Johns Hopkins University ... 417
Electro-Technical Education, by R. B. Owens ... 417
The Technical Education of the Electrical Engineer, by D. C. Jackson ... 418
A Large Electric Locomotive ... 424
The Dewey Electric Railway System, by W. S. Hays ... 424

FINANCIAL INTELLIGENCE: The Electrical Stock Market, 425; New Incorporations, 425; Affairs of the Companies, 425.

SPECIAL CORRESPONDENCE: New York Notes, 425; New England Notes, 426; Western Notes, 426; Answers to Correspondents, 426.

NEWS OF THE WEEK: The Telephone, 426; The Electric Light, 426; The Electric Railway, 427; Legal Notes, 427; Miscellaneous Notes, 427.

INDUSTRIAL AND TRADE NOTES ... 427
BUSINESS NOTICES ... 427
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 427

The Chicago Convention. THE general impression among the members in attendance at the Chicago Convention of the American Institute was that the programme arranged was a very interesting one, and that a careful study of the papers could not fail to be of great benefit to all the members of the Institute. It was regretted, however, that the rather crowded programme had not been handled in such a way as to permit of more discussion. It would seem to be much better in cases where papers are printed in advance, and can be read by those who take an interest in them, to have them presented by abstract, and the time that would otherwise be taken up in reading them in full could thus be given to their discussion by those whose investigations have led them along similar lines of study and research. The valuable discussions brought out by many of the Institute papers is rightly regarded as one of the most characteristic and praiseworthy features, and every possible encouragement should be given to members who desire to contribute to the work of the Institute in this way.

Traction Motors. THOSE who have followed the published literature on the subject of motors for electric railways will have noticed the great diversity of opinion regarding the preference of gearless, single or double reduction motors, commutated fields, etc., all of which tends to show that none of these methods are quite satisfactory. As is well known, one of the chief difficulties in all motors run on multiple arc circuits and started loaded is that owing to the low counter E. M. F. at the starting the rush of one current is very great; besides being difficult to take care of such currents, the efficiency must necessarily be low at starting. Mr. Leonard, in his Institute paper, published in another column, has attacked the problem in a novel and entirely different and apparently much more rational manner. His fundamental principle, already explained in our columns in connection with stationary motors, is simply to transform the 500-volt current on the car into one of any desired voltage capable of regulation; this latter current is then used to drive the motor, and as such a current can be given any voltage it can be adapted to any desired speed of motor without having to be cut down by a wasteful and expensive resistance; the efficiency therefore remains nearly constant. Theoretically this idea of transforming volts into ampères, so to speak, instead of cutting them down by resistance, appears to be a very rational one; it is only a question of whether it can be made practically on account, chiefly, of the triple motor which is required.

The Faure Patent in Germany. WHILE in this country the litigation concerning the Faure patent has resulted in tying up both companies, the Germans, like the French, have acknowledged the rights of Faure. The Supreme Court of Appeals of Leipzig has just delivered a judgment confirming the decision of the German Patent Office concerning Faure's patent, and thereby establishes its validity. It will be rememembered that a year or more ago a similar decision was reached in France. As we have so few accumulators here, the litigation in this country is of comparatively little interest, except in so far as it delays the development of the accumulator. It is a matter of no great concern, therefore, who is the winner here, if winner he may be called at all, but both in Germany and France the accumulator business is very large and prosperous, increasing continually. The accumulator there is a staple, reliable article of manufacture, here it is considered, like the electrical goods of the quack doctor, fit only for the ignorant and unsuspicious. But the accumulator when substantially made is a very convenient and useful accessory to an electric plant, even though many Americans think otherwise, and it is to be regretted very much that it has such a bad reputation here. As much of this is doubtless due to the lack of healthy competition, owing to the fear of a possible fundamental patent, it is to be hoped that a definite decision will soon be reached in this country too, in order that we may begin to make up for valuable time and reputation lost in this almost endless litigation.

Strength of Acid in Secondary Batteries. IN a recent paper before the Institution of Electrical Engineers, Dr. Gladstone, whose work in storage batteries has become so well known, shows how very much the E. M. F. is dependent on the degree of concentration of the sulphuric acid, and the important part which a variation in this concentration plays in the varying E. M. Fs. of charge and discharge. Some fully formed and carefully washed plates were placed in solutions of gradually increasing strength of acid and left there for 15 minutes with the following percentages of acid: 6.5, 21.7 and 43.0; the E. M. Fs. were respectively 1.887, 1.978, 2.170. He also showed that the E. M. F. depends furthermore on the strength of the acid at the negative as well as at the positive plates. From calculation, according to Lord Kelvin's law regarding the relation between the E. M. F. of the cell and the thermal value of the chemical actions contributing to it, he finds that the energy of PbO_2 and Pb, with pure sulphuric acid only, would be 2.627; by experiments it was found to be 2.607; with pure water the result is by calculation 1.35 and by experiment 1.36 volts; this leaves a very wide range of voltage between these two values. In charging, the current gas has to do extra work in concentrating sulphuric acid at the peroxide plate, and the energy equivalent to that work must be obtained from an increased potential difference. This explains why it is that the potential difference is so much greater during charge than during discharge. For a dyad gramme equivalent of sulphuric acid, concentrated from a 10 per cent. solution to one of 100 per cent., about 17,000 calories will be required, which is equal to .37 volt. The lesson to be learned from this is the desirability of promoting diffusion in the liquid of the cell so as to keep the acid as uniform as possible. In the usual forms the heavy acid flows down and accumulates at the bottom, which leads to differences of current density in different parts of the plates, gives rise to local action, and causes other troubles.

Long Distance Transmission. ALTHOUGH Europeans are apparently ahead of us in long distance transmission installations, yet there are some very interesting plants in operation in this country which many do not know about, probably because detailed descriptions have never been published. Two of these, one for light and one for power, are described in the paper of Mr. Scott, published in another column. The latter is of special interest because it is one in which a comparatively large synchronous alternating current motor is used, and besides this, it is not only the pioneer, but also the largest power transmission plant of its kind in this country. One hundred horse power are transmitted to a distance of nearly three miles over bare wires, at 3,000 volts and 167 alternations per second, the motor and generator being almost identical machines. The difficulty in such plants lies, of course, in the starting of the motor, but this appears to have been overcome very satisfactorily in this case, in which it is accomplished by means of a small Tesla motor and is stated to be a very simple matter. It requires but one man to do it and takes only two minutes. The description of the method of starting as also that of the details of the machines and their behavior when running, is well worth the attention of those interested in such transmission. A method said to be used largely in Europe for starting synchronous motors is to connect the motor and generator electrically, while the latter is at rest, then start the generator slowly, short circuited, as it were, by the motor, when the latter will start synchronously with the generator. This does not seem to have been tried in this plant and it is probably not as simple as it appears. A feature which reflects with great credit on the installers of this plant, and also speaks well for the system, is that, although running night and day, it has given no trouble. This is all the more creditable because it is the first one of its kind ever installed. It has been running just a year and appears to be a complete success. Some of the features of the long distance lighting plant described are also of interest, especially the subdivision of the transformers into a series group and the regulation for the loss of potential in the line and transformers, which latter is a very important feature in a long distance lighting plant, in which the loss in the lines cannot be neglected.

Electrical Education. ONE of the subjects which was apparently of special interest at the general meeting of the American Institute of Electrical Engineers was that of the education of electrical engineers and electricians. Among those attending the meeting were nine professors, who represented the courses of electrical engineering and physics of almost as many colleges; besides there were many who had very decided views regarding the preparation of the coming electricians at the colleges. A whole evening session was devoted to this subject, the papers being: One by Prof. R. B. Owens, of the University of Nebraska, and one by Prof. D. C. Jackson, of the University of Wisconsin. Both of these papers are well worth the attention of those interested in this subject. Prof. Owens dwelt particularly on the value of technical training as distinguished from the studies of pure science, without, however, giving the latter an inferior place. He places the engineer between the scientist and the skilled mechanic or handicraftsman, that is, "the man who, familiar with the results of scientific investigation and methods, uses both, by the help of the mechanic's skill, to minister the more effectively to the wants and will of an ever increasingly exacting public." An engineer should possess a certain familiarity with tools and shop methods, but need not necessarily be as skilled in their use as the mechanic. He approves of teaching this manual element in proper schools, such as manual training schools, in which the students receive sufficient training for a general knowledge of the subject without losing too much time in becoming a skilled mechanic. He advocates such training schools as preparatory to technical schools, claiming, and with right, that the latter should be classed with those of law and medicine. It was not very many years ago that the scientific departments in our universities were regarded as very inferior in rank to the so-called arts departments, in which Greek, Latin, literature and history were the chief studies; but more recently the tables have turned most decidedly, the ornamental but useless studies of dead languages, dead men and dead countries, in the latter department, are rapidly being replaced by the more useful studies in the scientific and engineering departments. Prof. Owens calls attention to the fact that higher education can never be made to pay for itself and that colleges must therefore remain dependent upon state aid or private munificence. Prof. Jackson, in his paper, indorses much that is contained in the other, and in addition puts particular stress on the acquirement of common sense knowledge and on teaching the student to think; this he claims, and we thoroughly agree with him, is of the greatest importance in making good engineers. Prof. Crocker, as well as others in their discussion, criticises very unfavorably the statement made some years ago by Sir William Thomson, that the electrical engineer should be nine-tenths mechanical and one-tenth electrical engineer; the prevailing opinion at the meeting appeared to be just the reverse of this opinion of Thomson's. An attempt to be both a mechanical and an electrical engineer cannot but result in failure. The fields are too large for any man to attempt to master both. Among other suggestions regarding the studies which a student of electrical engineering should be required to choose, Mr. Sprague proposed entomology, in order that they may become proficient in looking for "bugs."

The Chicago Meeting of the American Institute of Electrical Engineers.

The first meeting of the American Institute of Electrical Engineers ever held in the West convened in Chicago on Monday morning of last week, with quite a large attendance of delegates from different parts of the country. A number had arrived by trains from the East on Sunday afternoon and Monday morning, in addition to those who had come in from Western towns.

To any one acquainted with the delegates by far the most noticeable feature of the meeting was the very large representation of those who are engaged in the educational branch of electrical engineering. The programme arranged for the meeting included two papers on electro-technical education in addition to a discussion on the same subject by Professor Crocker, and this doubtless had considerable effect in bringing together so many of those who make a business of training electrical engineers. Cornell was represented by Prof. E. L. Nichols; the Ohio State University, by Prof. B. F. Thomas; Michigan University, by Prof. H. S. Carhart; Wisconsin State University, by Prof. D. C. Jackson; Minnesota State University, by Prof. George D. Shepardson; Nebraska State University, by Prof. R. B. Owens; the electrical department of Columbia College, by Prof. F. B. Crocker, and Prof. E. P. Roberts represented the ex-educators now engaged in the commercial development of applied electricity. This substantial backing of electrical educators gave unusual interest to the meeting, and, indeed, the best parts of the various discussions, and quite a number of the papers read, were contributed by these men.

The sessions of the Institute were continued through Monday, Tuesday and Wednesday. Two sessions were held on Monday, three on Tuesday and one on Wednesday. The programme as announced in advance was carried out with but slight change. Nearly all the papers announced were either read or presented by abstract, and a number of interesting discussions were brought out. On Monday afternoon a trip was made in a special car to the City of Pullman, where the extensive works of the Pullman Car Company were inspected under the escort of Mr. A. H. Bauer, the electrician of the company. The evening session on Monday was held at the rooms of the Chicago Electric Club, and was given up almost exclusively to the inaugural address of the new president, Mr. Frank J. Sprague. After this address there was a short discussion, in which ex-Mayor Cregier, of Chicago, took part. This session was followed by a collation given by the club. Among those present were many electricians of Chicago and vicinity. The affair was very enjoyable, and was followed by a number of speeches.

At the Tuesday morning session a number of papers were presented. The one which excited the most interesting discussion was that on the "Life and Efficiency Tests of Incandescent Lamps," by Prof. Thomas. In this discussion Mr. Howell, of the Edison Lamp Works, and Prof. E. P. Roberts, of the Swan Lamp Company, took a prominent part, and added much to the interest of the paper. The afternoon session of Tuesday was devoted chiefly to the discussion of electric mining machinery and long distance transmission of power. At the evening session on the same day, which was held at the rooms of the Chicago Electric Club owing to the political excitement at the hotel, the subject of the education of electrical engineers was thoroughly discussed. The two papers on the programme on this subject, one by Prof. Owens and the other by Prof. Jackson, were read. The discussion was opened by Prof. Crocker, who was followed by a number of those present.

It is at this session that the committee appointed at the last meeting in New York to consider the question of changing the method of nomination and election of officers of the Institute made its report. The substance of this report was that the ballot should be a secret one by mail, so that all members might have an opportunity to vote instead of only those who were present at the annual meeting in New York. The method proposed was quite similar to that used by other large engineering societies. It was thought best to lay this matter over until the fall meeting before acting on it, but there is very little doubt that it will be adopted. An informal vote was taken, which showed that the members present were quite unanimously in favor of adopting the new method of election. This session was closed by a paper by Mr. Carpenter, accompanied by illustrations of his heating and cooking apparatus in actual operation.

The last session was held on Wednesday morning, and was very largely taken up with the reading and discussion of railway papers, which were presented by Messrs. Perry, Leonard and Shepardson; but owing to the engagement to visit the World's Fair Grounds in the afternoon, the discussion of these papers was unfortunately cut short by the motion to postpone further discussion until the next fall meeting of the Institute in New York City.

The afternoon of Wednesday was given up to a very enjoyable trip in special cars provided by the Illinois Central Railroad Company to Jackson Park, the site of the new World's Fair Buildings. Prof. J. P. Barrett, chief of the electrical department of the World's Fair, and Mr. J. Allen Hornsby accompanied the party to the grounds. Special observation cars were provided at that end of the line by Chief Burnham, of the Construction Department, and the party was taken over the material track about the entire grounds, stopping at various points to inspect particular buildings in which electrical engineers were supposed to be interested, among them the Electricity and Transportation buildings. Mr. J. G. Hartigan, superintendent of the northern lines of the Illinois Central Railroad, accompanied the party as the representative of his road. This closed the general meeting, and the delegates nearly all left the city Wednesday evening and Thursday morning.

Among those who registered were the following:

From New York City: J. B. Williams, T. F. Smith, Chas. D. Shain, H. Ward Leonard, S. S. Bogart, Herbert Laws Webb, T. C. Martin, G. M. Phelps, Carl Hering, Edward Caldwell, R. F. Outcault, F. J. Sprague, Nelson W. Perry, R. W. Pope, F. B. Crocker, C. E. Emery and C. L. Cornell.

From Chicago: R. I. Hitt, E. A. Sperry, M. J. Sullivan, E. F. Seixas, J. L. Barclay, C. F. Street, C. C. Haskins, J. B. Gregg, J. F. Connor, F. B. Badt, S. D. Flood, W. F. Collins, C. K. MacFadden, Geo. Cutter, L. L. Summers, Fred De Land, M. B. Spier, H. J. O'Connell, W. E. Cothren, E. M. Barton, C. A. Brown, M. J. Bulkley, T. D. Ray and W. N. Smith.

From other cities: H. S. Carhart, Ann Arbor, Mich.; Capt. A. de Khotinsky, Boston; Chas. F. Scott, Pittsburgh; Frank C. Perkins, Dunkirk, N. Y.; Harry N. Marvin, Schenectady, N. Y.; F. P. Mills, Ishpeming, Mich.; Edw. N. Nichols, Ithaca, N. Y.; E. P. Roberts, Cleveland; E. G. Willyoung, Philadelphia; E. A. Merrill, Ithaca, N. Y.; C. H. Dunbarr, Pittsfield, Mass.; Edw. P. Burch, Minneapolis; H. S. Howard, Minneapolis; Percy Martin, Columbus, O.; W. R. Cleveland, Cleveland, O.; C. S. Bradly, Avon, N. Y.; C. D. Jackson, Madison, Wis.; Frank B. Rae, Detroit; R. B. Owens, Lincoln, Mass.; F. R. Upton, Orange, N. Y.; Thos. D. Lockwood, Boston; A. L. Hadley, Ft. Wayne; John W. Howell, Newark, N. J.; Leo Daft, Seattle, Wash.; B. F. Thomas, Columbus, O.; M. O'Dee, Notre Dame, Ind.; R. J. Miller, Clinton, Ia.; C. Wellman Park, Troy, N. Y; Wm. M. Porter, Detroit; Chandler P. Gilman, Milwaukee; C. H. Sames, Rockford, Ill.; A. H. Cowles, Cleveland, O.; B. H. Highlands, Clinton, Ia.; A. F. Opperman, Hornellsville, N. Y.; L. V. Lindon, Hornellsville, N. Y.; Geo. D. Shepardson, Minneapolis; Jno. R. H. Staley, Joliet, Ill.; P. P. Beals, Buffalo, N. Y.; E. A. Carolan, Ithaca, N. Y.

The Efficiency of Steam Locomotives at High Speed.

In The Electrical World of May 21, 1892, a preliminary statement was made concerning an efficiency test of high speed locomotives by Mr. Angus Sinclair, editor of *Locomotive Engineering*. At that time no definite data could be obtained, but complete details are published under Mr. Sinclair's name in the June number of his journal. These results are of considerable interest to electrical engineers, inasmuch as there is considerable discussion at the present time regarding the relative economies of electrical and steam methods of propulsion for transportation of heavy traffic over long distances. The results published modify quite materially any conclusions that might have been drawn from the first accounts of the test, since it appears that the coal consumption was 3¼ pounds per horse-power per hour instead of 2⅛ pounds, as was claimed at first. It also appears that this is an estimated result rather than one which was obtained by actual measurement. This was, of course, to be expected owing to the impossibility of ascertaining by indicator cards the exact amount of work done in drawing a train over the run of 143 miles from New York to Albany.

As previously stated, the test was made on the Empire State Express, now making daily runs between New York and Buffalo at an average speed of 52½ miles per hour. The engine cylinders are 19 × 24 inches, the driving wheels 78 inches in diameter, the heating surface 1,821½ square feet, and the steam pressure 170 pounds. In Mr. Sinclair's report it is stated that there is no peculiarity about the engine apart from an exceptionally large boiler and steam passages sufficiently large to permit the steam to get in and out with little wire drawing. Indicator cards were taken with a Tabor indicator having a five-inch drum and a spring with a scale of 100 pounds to the inch. A Crosby revolution counter was used to record the speed.

The train consisted of four coaches weighing, with the estimated load, 340,000 pounds. The engine and tender in working order weigh 200,000 pounds, so that a total weight of 270 tons represented the load which the locomotive was compelled to draw.

The first indicator card was taken when the engine was lifting the train into full speed and this showed a mean cylinder pressure of 59 pounds. According to this diagram the power exerted on the rails to move the train was 6,553 pounds, or 24 pounds per ton. The speed was 37 miles an hour, which it was thought could be maintained by half this expenditure of power, the remainder of course being expended in accelerating the speed. When a speed of nearly 60 miles an hour was reached and the engine had settled down to steady running, neither accelerating its velocity or letting it decrease, a card was taken which represents the work done in this way and measures the power required to keep the train running at a mile a minute. The average cylinder pressure under these conditions was 40.7 pounds, representing a total traction force of 4,520 pounds without making deductions for friction. If 10 per cent. be allowed for friction it leaves 15 pounds per ton to keep the train going at the speed named. Although this is far below the figures given in engineering manuals, Mr. Sinclair says that it is correct, since nearly 20 diagrams were taken when the train was running at this even speed, and the results given are a fair representation of the work done.

Another diagram was taken when the engine was making 340 revolutions per minute, which is within a few feet of 79 miles per hour. Mr. Sinclair obtained a phenomenally good diagram under these conditions, for the piston speed was no less than 1,360 feet per minute.

Throughout the trip seven pounds of water were evaporated per pound of coal. As nearly as could be estimated the work of pulling the train from New York to Albany was done, as was stated above, on a coal consumption of three and one-eighth pounds per horse power per hour. Concerning the work of the engine at high speeds, it is stated that there was very little jar, and that it rode like a coach, passing the sharpest curves very smoothly. When running close to 80 miles an hour the machinery worked as smoothly as at the lower speeds and no trace was to be observed of hammer blow or other disturbance due to the heavy weight swinging round at a great velocity.

Instead of reproducing the indicator cards we give here, with the particulars of the 12 diagrams which Mr. Sinclair has selected as typical of those taken during the two trial trips between New York and Albany.

PARTICULARS OF INDICATOR DIAGRAM.

No. of Diagr'm.	Throttle opening.	Reverse lever notch.	Point of cut-off.	Boiler pressure.	Rev.'s per minute.	Speed in miles per hour.	Indicated horse power.
1	¼	18	8¼	160	160	37.1	648.3
2	¼	18	8½	165	260	60.8	728
3	⅛	18	8½	170	190	44	551
4	⅛	18	8½	170	250	58	891
5	¼	18	8½	160	260	60	960
6	⅜	19	7¼	160	298	69	983
7	⅜	19	7¼	160	304	70.5	977
8	⅜	19	7¼	165	296	68.6	972
9	⅜	19	7¼	165	300	69.6	1,045
10	⅜	19	7¼	170	304	70 5	1,059
11	⅜	19	7¼	165	340	78.9	1,120
12	⅜	19	7¼	165	310	71.9	1,026

In this connection it will be of interest to note the unusual record recently made in locomotive speeds. A compound engine running on the Central Railroad of New Jersey drawing a regular train on the Royal Blue line traveled over a single mile in 39½ seconds; a very remarkable speed and probably the fastest time on record. If this speed could be maintained between New York and Washington it would reduce the time, without stops, to 2½ hours, instead of five hours, which is now the fastest regular time. In the same issue of *Locomotive Engineering* from which Mr. Sinclair's results are taken Mr. Harris Tabor, in commenting on the performance of this engine on the Jersey Central Railroad, says: "If speed above 60 miles per hour is to be sought economically, larger wheels and cylinders will follow. The lesson of the cards published insists upon the piston speed being kept below 1,000 feet per minute, even when cylinders are compounded, if the best duty be expected from the motive power."

Mr. Tabor also says: "Attempts at higher speeds will probably result in larger cylinders and drivers. The Pennsylvania road is building a fast passenger compound with drivers 84 inches in diameter, and the New York Central has under way a simple engine with drivers the same size. If these engines have the boiler and cylinder capacity, they can easily add 10 per cent. to the speed of the wonderful Empire State express. We may look for fast riding when the compound, with 90 inch drivers, said to be under consideration by a prominent builder of locomotives, is on the rails. This locomotive may not inaugurate the 100-mile gait that so many seem to be looking for, but the chances are that she will demonstrate the fact that a limited train of three cars may be pulled at that speed over good roads, if enough people are willing to pay for the luxury of riding that fast, and are willing to take chances of the train being controlled by the system of brakes now in use."

Obituary.

Mr. George F. Green, of Kalamazoo, Mich., died last week at his home in that city. Our readers will remember that an electric railway patent was recently issued to Mr. Green which had been in the patent office for a number of years, and which showed that he was one of the earliest inventors in the electric railway field. His portrait and a fac-simile of one of his early drawings, together with the details of his patent, will be found in The Electrical World of Jan. 9, 1892. Mr. Green, who was 60 years old at the time of his death, was also an inventor in other fields, and is said to have devised the first self-binding reaper and a pneumatic shutter for cameras. The press dispatches state that he was working on his electric railway schemes at the time of his death.

Gas Engines for Dynamo Driving.

The German Imperial Continental Gas Association, Dessau, after running dynamos by means of gas motors for five years, tabulates the advantages of the system as follows, says the *Gas World*: 1. Small amount of space required. 2. Small consumption of water; five to six gallons per horse or less. 3. No coal to carry; independent of railway station. 4. No smoke. 5. No explosions. 6. Cheaper than steam engines in respect of (1) ground required; (2) relative convenience of gas motors rather than steam engines in a town, whence greater choice of place within a town, and smaller distances to lay cables; (3) gas motors above 100 h. p. being cheaper than steam engines, boilers, chimneys, etc. 7. Less loss of electricity, because station more favorably situated. 8. Less attendance and wages. 9. Exact control over fuel. 10. More regular working and greater security of power to meet unforeseen demands. 11. Cost of fuel can be reckoned (the gas company running the electric station) at the full cost price of the gas supply. Gas motors of 120 h. p. now cost to put up about half what steam engines do; and in the future the price of still larger gas motors may be expected to fall.

Electric Pipe Bending.

SO numerous are the applications of electricity to the useful arts at the present time that any new departure has ceased to excite surprise. That electrical apparatus has many advantages over other forms is now well known and its rapid introduction is evidence of its superiority. It is more compact, far more flexible, performs the work with greater, or at least the same economy, and with much greater certainty of uniform results.

One of the most recent applications of electricity is to the heating and bending of pipes. This process has been attended with such success that it is probable that in the future the greater part of this class of work will be accomplished by electrical means. For nearly a year electricity has been employed by the Electric Pipe Bending Company, and many advantages over the older and more cumbersome methods are claimed. The works of this company are at Harrison, N. J., just across the Pennsylvania Railroad tracks from the Edison Lamp Works. The process is simple but very interesting, especially to one who has watched the development of electric welding.

The power is furnished by a McIntosh & Seymour 125-h. p. engine, to which is belted a generator, an air compressor and line shaft. All these machines are arranged along the end of the building and occupy very little room. The generator is of the alternator type D 60 E E of the Thomson Electric Welding Company's make, designed especially for this character of work. It is shown with its exciter in Fig. 5. All the circuits are controlled by a switchboard, which is placed on the wall near the dynamo.

The general process of pipe bending is very well shown in Fig. 3. The pipe is firmly clamped in the jaws of the heater, which is the machine shown in the centre of the illustration, at the point where the bend is to be made. The current is then turned on by means of a cord or lever which controls a spring switch on the ceiling.

When the pipe has been brought to the proper heat, which is determined by the trained eye of the workman, it is released from the clamps and moved forward until the heated portion passes between the rolls seen at the left in Fig. 3. The end of the pipe is secured to a carriage moving on a circular track and as this carriage is pushed around the pipe is bent as easily and prettily as if it were India-rubber. Where the pipe is in short pieces or a continuous coil is made it becomes necessary to weld different sections together. This is accomplished by an ordinary welding machine, which is shown at the right of Fig. 3. After a weld is made the pipe is treated as one continuous piece and the process is repeated as above.

The electric heater, which is shown more in detail in Fig. 1, is one of the most interesting pieces of apparatus used for this work. Its construction is very simple. It receives its current from the generator referred to above, the pressure in the primary being approximately 300 volts. This is converted down to a pressure of from one to six volts, according to the nature of the work. The secondary circuit consists of massive copper bars, the jaws of the heater being part of this circuit and the pipe when clamped between them completing the circuit. The cross-section of the copper in the secondary circuit is about 16 square inches. In order to prevent undue heating a water circulation is required, and this is supplied through rubber tubes or pipes, which are seen in the illustrations. This machine, as well as all the others, is grounded to prevent any trouble in case of leaks. The current is controlled by a reactive coil or "kicker," represented in Fig. 2, which is placed in the primary circuit close to the heater where it can be conveniently reached. The electromotive force of the primary and therefore the current of the secondary is readily controlled by this reactive coil. The current which flows in the secondary of course varies with the nature of the work, but the ampères at least reach up among the thousands, necessitating a very large amount of copper in the circuit.

The action of this machine is very rapid and by proper forcing an ordinary section of iron pipe can be brought to a white heat in from 30 to 60 seconds, although a little more than this time is ordinarily allowed. It is thus seen that the generator can be forced considerably beyond its normal capacity, as the time required is so very short that dangerous heating could hardly occur.

But little energy is wasted for the heat is applied directly and only to the spot where it is needed. At the same instant, while the pipe between the jaws is at a white heat, at a distance of two or three inches outside of them the iron is scarcely warmed. This makes it possible to handle the work with perfect impunity.

The welder, which is shown in detail in Fig. 6, is very similar in construction to the heater, except that the clamps or terminals are necessarily very much closer together. In welding two pieces of pipe the end of one section is carefully faced, while the other is turned to a short bevel. The two ends are then put into the welder against one another and clamped and the current turned on. As they heat pressure is gradually applied, and in a few seconds or a minute the two pieces are firmly welded together. They are then removed from the clamps and finished with a hammer, so as to bring the weld down to the uniform section of the pipe as nearly as possible. This is accomplished by an ingenious pneumatic hammer, which does the work much more rapidly and much better than could be done by hand. This hammer is shown in Fig. 4 Its energy is received through rubber tubes from a Clayton air compressor belted directly to the engine, as above described. The hammers in use in this factory differ from the one shown in the illustration only by having the compressed air supplied through the handle; that is, the rubber tube is attached directly to the end of one of the handles, thus making it somewhat more convenient. The hammer has only to be run around the weld several times, when its rapid blows on all sides bring down the weld to the required size. The current is regulated by a reactive coil similar to the one used with the heater.

The welding and heating apparatus are similar to those employed for a like kind of work elsewhere, but the bending apparatus was designed at these works, and is found to be an improvement over the old form. Fig. 3 gives a very good representation of its main features, and renders any further explanation unnecessary. The rolls are adapted in size to the different sizes of pipe, and these can be easily replaced. It was formerly the custom to bend the pipe over a sharp point, but this resulted in destroying its cylindrical shape, and was not satisfactory. The present apparatus bends the pipe very easily, and insures a fair and perfect bend.

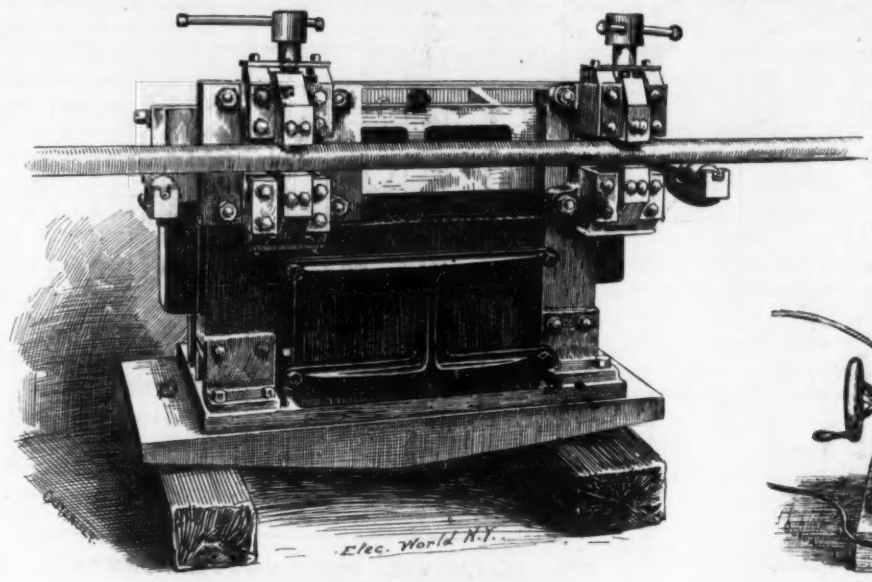


FIG. 1.—ELECTRIC HEATER

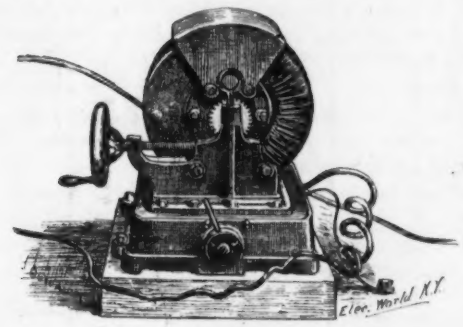


FIG. 2.—REACTION COIL.

The shop contains two sets of apparatus such as shown in Fig. 3, besides an extra heater, a furnace for heating pipe for coils, lathes for finishing the pipe, traveling cranes, etc.

The whole operation of welding and bending the pipe can be conducted with remarkable rapidity and the quality of the work is superior in many respects to that done by the old methods. The entire absence of dirt, or smoke, which the use of furnaces involves, is a point in favor of the electrical method. Considerable time is also saved. It is well known that the welds are more uniform and better in many respects than those made by hand or mechanical processes. This is a very essential point in pipe bending, as a large portion of the pipes are used for refrigerators and similar work where it is quite necessary that the welds should be perfect and there should be no leaks. The pipes are all tested, after being welded and bent, by hydraulic and air pressures.

All classes of work can be done by this process and pipes are bent from sizes varying from one-half up to four inches, and there is no reason why larger pipes could not also be handled.

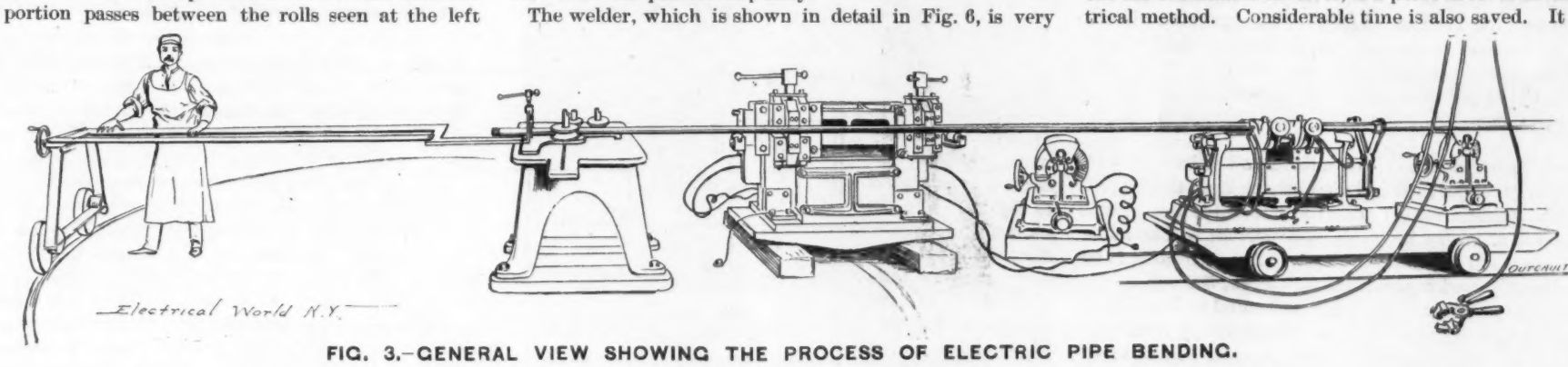


FIG. 3.—GENERAL VIEW SHOWING THE PROCESS OF ELECTRIC PIPE BENDING.

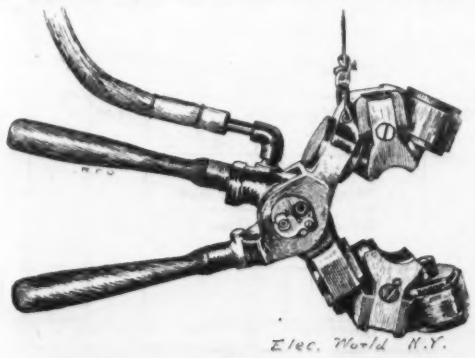


FIG. 4.—PNEUMATIC HAMMER.

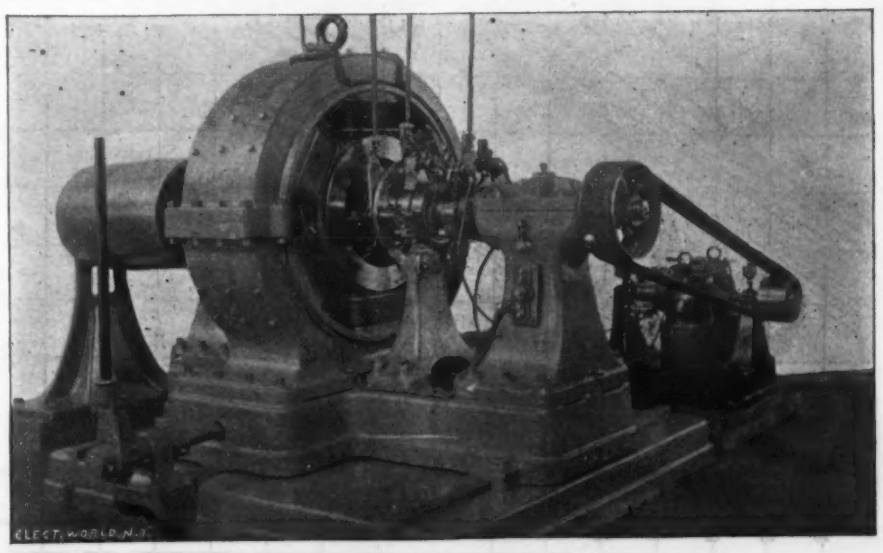


FIG. 5.—GENERATOR.

Utilization of Smoke.

Experiments have been carried on in England by Mr. Mond, the object of which is to utilize he waste products in smoke. The smoke is led from the chimneys into a waterspray condenser, where it is claimed that he obtains four tons of sulphate of ammonia for every 125 tons of coal burned. This waste product is said to be worth in the neighborhood of $60 per ton. If the reports are correct, this would make the waste product worth about $2 for every ton of coal burned; this appears so great that it is very questionable whether the figures given are reliable. At all events the subject might be worth looking into by electrical engineers in charge of large stations.

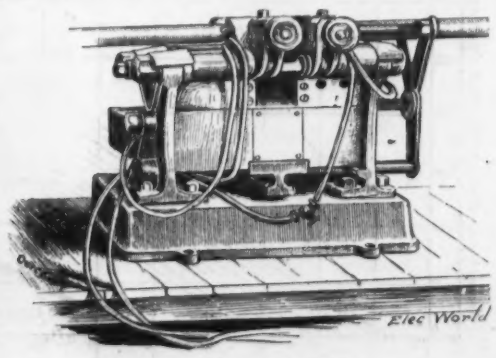


FIG. 6.—WELDER.

Electricity in the Belt Line Tunnel.

While the minor details of the Belt Line tunnel at Baltimore have not been decided upon, the essential features of the installation are now known. The 80-ton locomotives will be capable of developing 1,200 h. p. each. There will

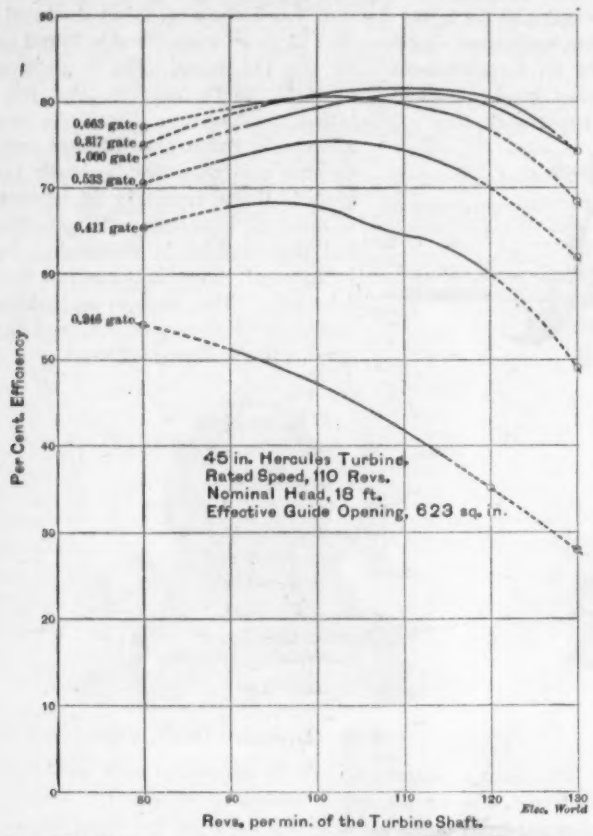


FIG. 13.—CURVES OF EFFICIENCY OF 45 INCH HERCULES TURBINE AT CERTAIN FIXED GATES AND VARIED SPEEDS.

be four driving axles, on each of which will be keyed the armature of a 300-h. p. motor. The series multiple system of control will be used. Two of the locomotives will be in constant use, the third being held for emergencies. In addition to hauling trains through the tunnel, they will be employed, when necessary, to help push heavy freight trains up the 1¼ per cent. grade just outside the tunnel. It is expected that 400 trains will pass through the tunnel daily.

The conductors will be either a third rail of iron or some sort of a large copper tube laid above the ties and thoroughly insulated. Feeders carried along the side of the tunnel will be tapped in at proper intervals. The current will be taken off by some form of sliding contact. The potential is to be that ordinarily used in street railway work, 500 volts.

The power station will probably be located at Jones Falls and have a capacity of 3,000 h. p. There will be four compound Corliss engines of about 750 h. p. each belted to or directly coupled to the generators, no countershaft being employed.

The tunnel will be lighted throughout by electricity and an arrangement will be made to turn on the electric lamps of the train as it enters the tunnel and extinguish them as it leaves it.

Although the Thomson-Houston locomotive at Whitinsville has done good work, hauling trains of 200 to 300 tons at five miles per hour, this will be the first use of electric locomotives on any large scale at high speeds, and its effect on electric railroading will be very great. It is understood that Frank J. Sprague is building a 700 h. p. locomotive for Henry Villard for the Northern Pacific terminals in Chicago and that the Thomson-Houston company will construct one of different design but of the same size for the same work.

Test of the Neversink Mountain Electric Road.—IV.*

BY HERMANN S. HERING AND WILLIAM S. ALDRICH,
OF JOHNS HOPKINS UNIVERSITY.

VI.—THE TEST OF THE POWER PLANT.

Outline of Test.—Observations were made to determine the distribution of power, the losses and efficiencies, from the hydraulic head of the water to the electrical output of the dynamos. Various readings were taken at the turbines with no external load, to get the several frictional losses, from the turbine shaft to the dynamos. Another series of readings were taken during a heavy excursion on the road.

Through the kindness of the Holyoke Machine Co., the authors were furnished with a complete sheet of the *actual* performance of a 45-inch Hercules turbine of exactly similar design to those here used. This test was made by the Holyoke Water Power Co., at their testing flume, to determine the actual performance of the turbine at different proportional gate openings and speeds. The authors have carefully plotted the tabulated results of this test in the curves shown in Fig. 11. From these they have derived the horse-power curves in Fig. 12. The observations necessary therefore, during the station test, were those of the speed of the turbine shaft and the position of the speed gate wheel, the number of turns of the latter giving proportional openings of the gate.

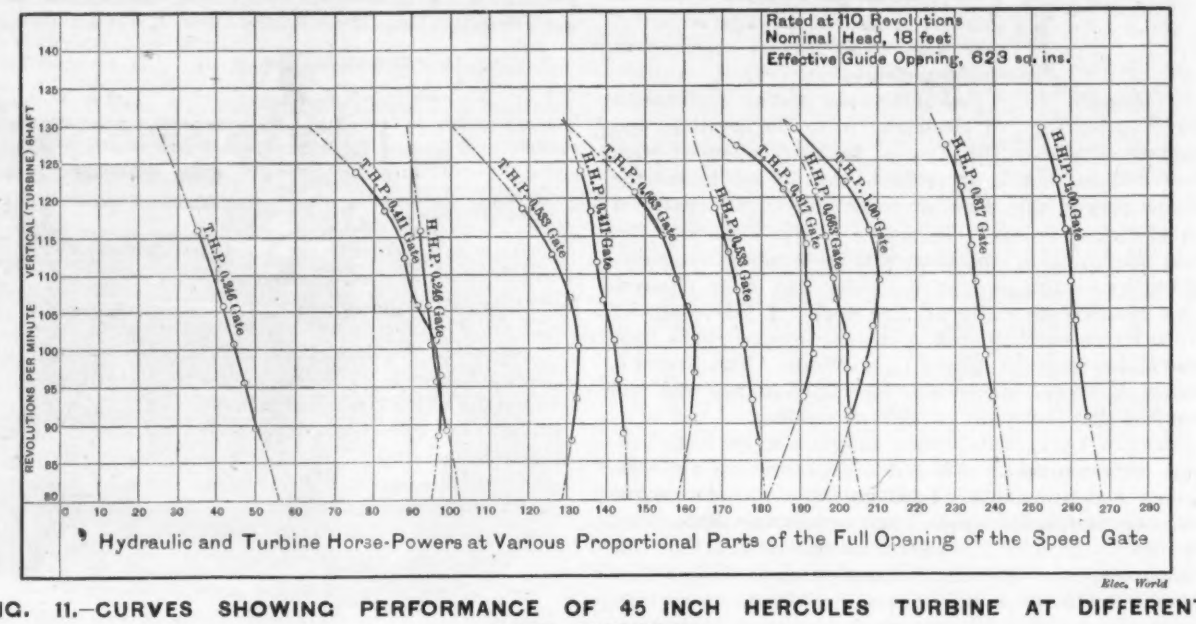

Rated at 110 Revolutions
Nominal Head, 18 feet
Effective Guide Opening, 623 sq. ins.
REVOLUTIONS PER MINUTE VERTICAL (TURBINE) SHAFT
T. H. P. 0.246 Gate
T. H. P. 0.411 Gate
H. H. P. 0.246 Gate
T. H. P. 0.533 Gate
H. H. P. 0.411 Gate
T. H. P. 0.663 Gate
H. H. P. 0.533 Gate
T. H. P. 0.817 Gate
H. H. P. 0.663 Gate
T. H. P. 1.00 Gate
H. H. P. 0.817 Gate
H. H. P. 1.00 Gate
Hydraulic and Turbine Horse-Powers at Various Proportional Parts of the Full Opening of the Speed Gate
Elec. World

FIG. 11.—CURVES SHOWING PERFORMANCE OF 45 INCH HERCULES TURBINE AT DIFFERENT GATE OPENINGS.

The electrical output of the station was determined by means of calibrated ammeters and voltmeters placed in circuit at the switchboard. The readings were taken simultaneously every minute, and whenever changes occurred within the minute they were noted and timed to seconds. In this way the complete station performance has been plotted on a time base.

The Turbine Performance.—The nominal head was 18 feet,

*For the first, second and third sections of this article see THE ELECTRICAL WORLD of May 28, June 4 and 11, 1892.

the surveyed difference of level between the head and tail waters; but the head acting on the wheel, or the effective head, varied, as usual, with the opening of the gate and the speed. At full gate opening it was 16 feet, while at closed gate it increased to nearly 18 feet.

The theoretical performance at some standard and constant head is the one usually taken for comparing the efficiencies of turbines, but does not serve the present purpose in determining the actual performance, under the conditions of every day work of these turbines at the Neversink power house, the variations of effective head entering at the Holyoke testing flume, where the dynamometric horse power of the turbine was determined. As it is entirely outside the province of this article to enter into any comparative elements of turbine performance, the observations were not thus reduced.

The turbine horse power (T. H. P.) curves of Figs. 11 and 12 show the actual dynamometric horse power developed by the wheel, and not what would have been developed at an assumed constant head as a standard basis

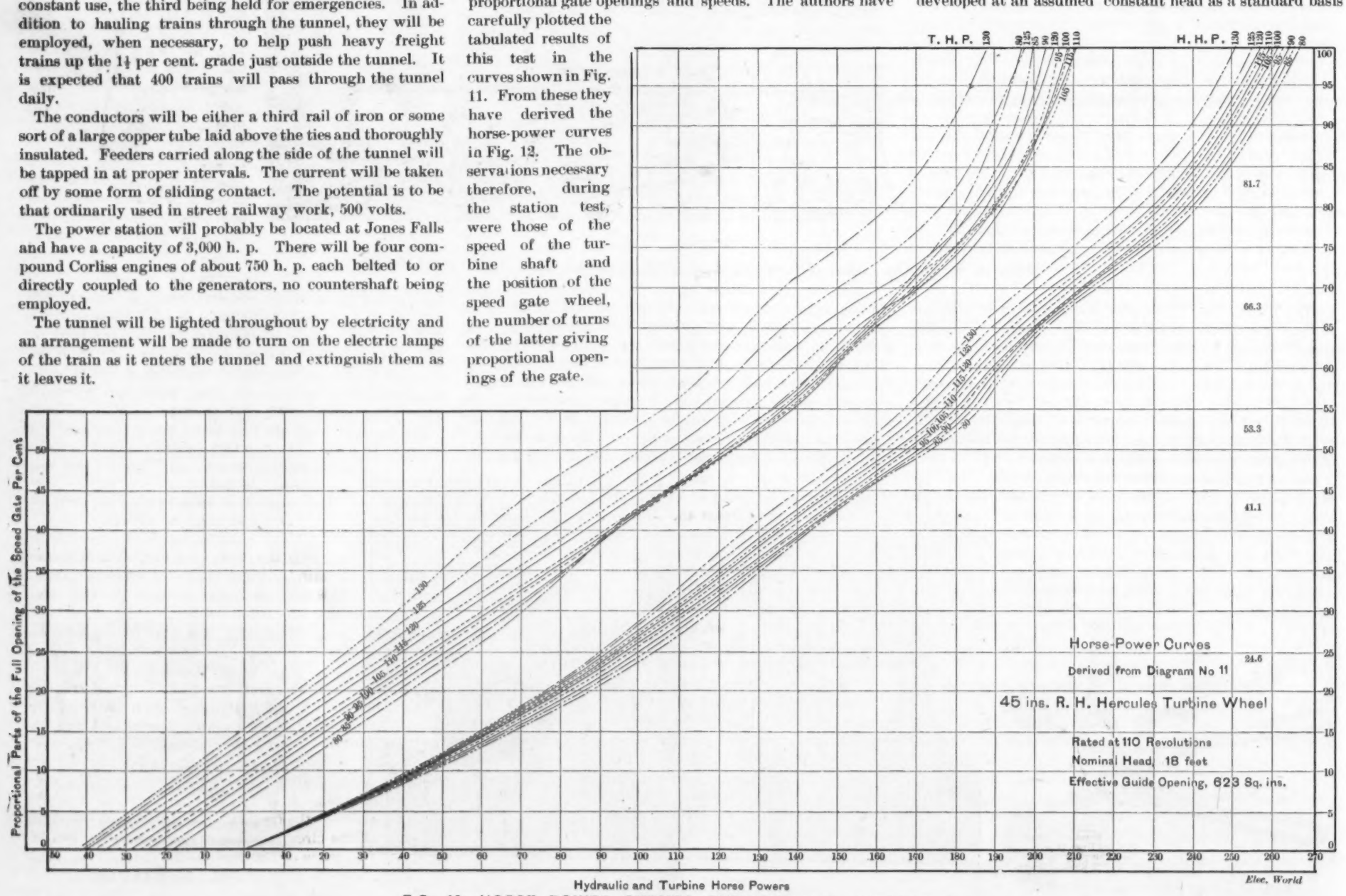


FIG. 12.—HORSE POWER CURVES, DERIVED FROM DIAGRAM 11.

for comparison. The hydraulic horse power (H. H. P.) curves as plotted were computed from the quantity of water discharged by the wheel and the head acting on the wheel, as determined at the testing flume. The curves of Fig. 12 have, therefore, been used to get the actual power developed at the turbine shaft for the different gate openings and speeds during the station test.

The H. H. P. curves will be seen to have an almost constant inclination, while the T. H. P. curves have a characteristic convexity, indicating that speed at which the tur-

bine will develop its maximum power for any particular gate opening. This may be called the "critical speed" at that gate. For example, at 1.00 (full) gate the maximum horse power developed is 210, at a speed of 110; at 0.533 gate the maximum T. H. P. is 133, at 100 revolutions. The horizontal distance along any speed line between the H. H. P. and T. H. P. curves for a given gate represents the power lost in the turbine at that speed and gate. Thus, at 100 revolutions and 1.00 gate there is 54 h. p. lost in turbine

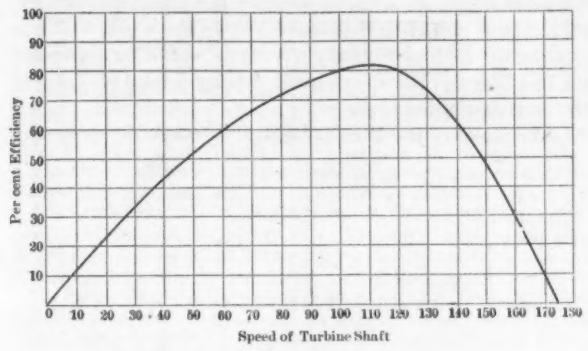


FIG. 14.

friction, as measured on the 100 speed line, from 208 to 262. This gives an efficiency of 79.3 per cent. Selecting the speed at which the distance between these curves is a minimum we obtain the maximum efficiency. The best speeds for the maximum efficiency and output for any gate are not identical, though they occur very closely together in the curves.

As a few of the speeds in the Neversink test were beyond the range of those on the test-sheet furnished, the authors have assumed a fair prolongation of the curves to 80 and 130 revolutions, in the general direction indicated.

From the gate curves at different speeds and horse powers, of Fig. 11, the speed curves at different gates and horse powers of Fig. 12 have been plotted. These are much more convenient for finding the horse powers than the former curves. The turbine friction at any gate is the horizontal distance between the corresponding speed curves.

The intersections of the T. H. P. speed curves with the vertical zero line simply represent the gates and speeds corresponding to no output. To the left of this line they represent what may be termed "negative" horse powers; that is, the amount of power required to drive the turbine from some external source; as, for instance, when coupled up with another turbine. This peculiar feature will appear prominently in the plotted results of the performance of each turbine. The intersections of these curves with the horizontal zero line indicate the power required to drive the turbine at different speeds with its gate closed.

Fig. 13 shows a series of curves of efficiency at different speeds for several fixed gate openings, as derived from Fig. 11. The critical speeds are different for the points of maximum efficiency at the several gate openings. Thus, at 1.00 gate, the maximum efficiency (81 per cent.) is at that point on the curve having a maximum ordinate at the speed of 113 revolutions. The portions beyond 90 and 120 revolutions, shown in dotted lines, correspond to the prolongations beyond these same speeds in Fig. 11.

Fig. 14 represents a completed curve of efficiency; from an initial zero, the curve passes through maximum to zero efficiency, at which point the turbine attains its highest speed when allowed to run empty. Another characteristic of the curves of Fig. 13 is that if any horizontal line be drawn somewhat near its vertex, the segment of that line will be bisected (approximately) by the maximum ordinate.

The mean speed of the turbines during the test was 100 revolutions, while the rated speed is 110. The curves of Fig. 15 show the efficiency at these two speeds for various

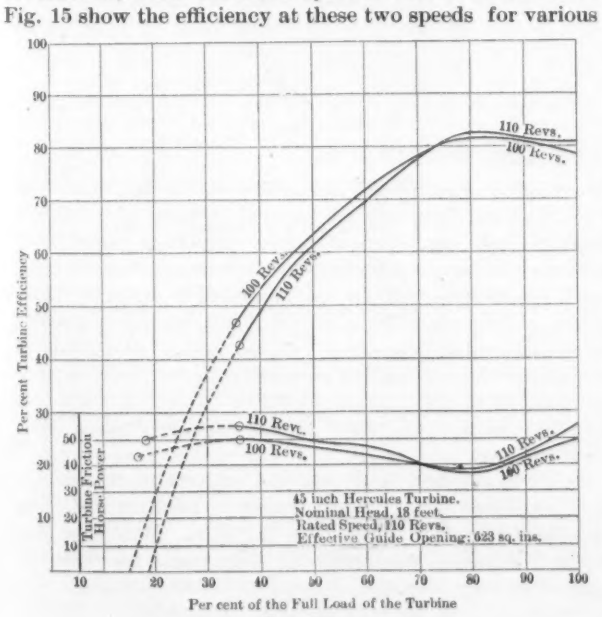


FIG. 15.

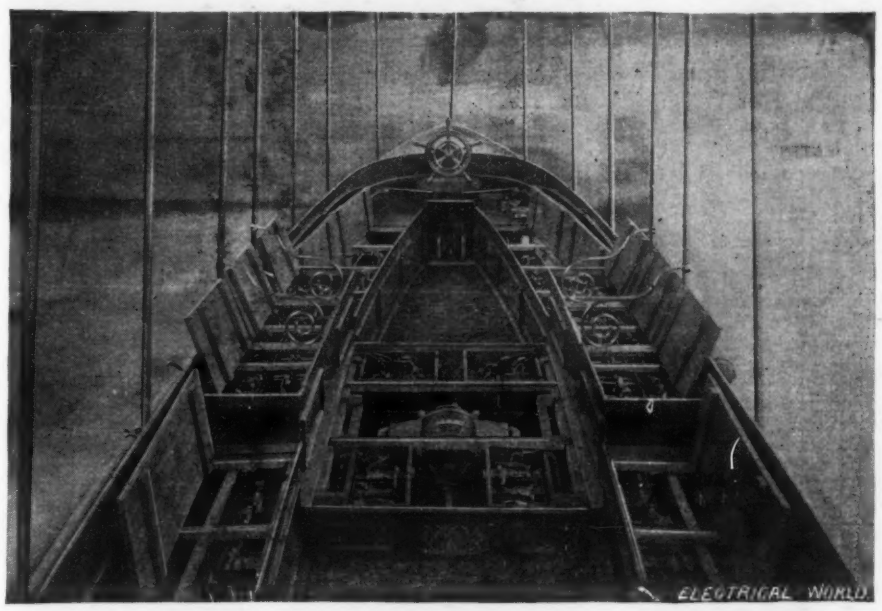
proportional parts of the full load. Each curve has a maximum ordinate at 82.5 per cent. of the full load, at which point the efficiencies are about 82.2 and 82.7, respectively. The per cent. of power lost in turbine friction at any per cent. of full load is found by subtracting the efficiency at that point from 100 per cent. By simply inverting the diagram and reading from 100, as a base line, the ordinates then represent the per cent. of turbine friction at the various proportional loads. The turbine friction horse powers are shown in the lower curves on the same horizontal scale of proportional parts of full load. It will be seen that the turbine friction horse power is not constant throughout the various loads under constant speed. The dotted lines refer, as before, to the prolongations of Fig. 11.

A New Electric Launch.

The accompanying illustration represents the electric launch Electra, built by the Electric Launch and Navigation Company, and described in THE ELECTRICAL WORLD of last week. This view shows the launch after the cushions have been removed and the floor raised. The batteries and motor can be plainly seen. Forward, under the deck, is the controlling device, consisting of switches and rheostat combined with a wheel by which they are operated. This wheel is mounted upon the hollow shaft that carries the steering wheel, so that the helmsman can control the boat without removing his hand from the wheel, which is a very excellent arrangement.

The Best Frequency for Alternating Currents.*

The question of what is, on the whole, the best frequency to employ in alternating current work has never been very seriously studied. The early Siemens machines gave low frequencies, and the original Ferranti dynamos gave about 250 periods per second. In America the general practice is 130 per second, while in England 100 is the most common, though some stations run as low as 70 periods per second. On the Continent frequencies of 60 and lower are to be met with, in some cases even so low as 40 or 45. In some of the multiple current systems extremely low frequencies obtain.



INTERIOR ARRANGEMENT OF THE ELECTRIC LAUNCH "ELECTRA."

In considering the best frequency, it is not sufficient to consider the dynamo alone, or the transformers or motors by themselves. All should be taken into account and a balance struck. Beginning at the central station, the dynamos may be considered first. The alternating current machines now made are somewhat primitive in design, comparatively few being much in advance of the alternating machines made in the early days. If an alternator is built up of a multitude of small magnets acting on a multitude of small armature coils, it is obvious that the lower the frequency the better with a given angular velocity. A simple machine with 24 poles, running at 500 revolutions per minute, gives a frequency of 100. If a second machine has only 12 poles, each of twice the sectional area of those of the first machine, the ampère turns on each field remaining the same, the power taken in excitation is less, for though each coil contains more wire, it does not contain anything like twice as much. The same reasoning applies to the armature. A machine with less armature loss and less excitation loss is thus produced, and produced more cheaply, as it is simpler and has less copper and less work upon it. On the other hand, a limit is soon reached, as large magnets mean increased armature reaction, so that, though the armature loss by resistance is less, the dynamo does not regulate so well. Therefore, for the ordinary old-fashioned dynamo, a moderate frequency is, no doubt, best. The difficulty of making dynamos with high frequencies has been enhanced by the custom of driving direct at low speeds. It is to be hoped that the inefficiency and clumsiness of the manifold dynamo will soon drive it out of the market, to be replaced by machines with single armature coils, or single field coils, or both. In such machines as the "Mordey" a single exciting coil is employed. The idea is quite old, but it is good nevertheless. In a dynamo of this type the armature loss is roughly doubled to save loss in the field. If the dynamo is generally running at full load this arrangement is bad, but if it is not, the armature loss does not matter to any serious extent. In a Mordey machine, therefore, there is comparatively little difficulty or expense in producing any frequency within reasonable limits. In another form of Mordey machine there is only one armature coil and one field ceil. In the Rankine-Kennedy machine, described and illustrated in *Industries* some time ago (see vol. xi., page 449), there are two armature and two field coils. In these machines it is as easy to have a high frequency as a low one. The single field coil arrangement used by Mr. C. E. L. Brown in the Lauffen dynamo, again, reduces the excitation loss without increasing the armature loss. In this type of dynamo high frequencies are as easy to attain as low; in fact, in this form, which has a small air space and a good deal of stray field, the armature reaction is considerable, so a rather high frequency is best. We may, therefore, say that, with well designed dynamos, the frequency can be made to suit the rest of the system.

The next question is that of running the generators in parallel. Many electrical engineers still have very vague ideas about running machines in parallel. Some argue that machines with light revolving armatures will not run in parallel, because the armatures have not inertia enough to smooth the impulses down. A rough calculation of the energy of inertia in even a light armature will show that this view is fallacious. Another common idea is that high frequency machines will not run in parallel and low frequency dynamos will. There is no ground for this statement. Of course, some low frequency may run better than some high frequency machines, but the converse is also true. This is merely one of those vague statements that are apt to pass current as truth in subjects not very generally understood. We may take it that machines can be made to run together at any frequencies desired.

The next part of the system to be considered is the conductor. Of course, in all conductors there is less loss by skin effects with low than with high frequencies. In all practical cases of distribution the skin effect is too small to be worth considering even with high frequencies. The leads, need, therefore, hardly be considered in this discussion.

Coming now to the transformers, we have to consider both the closed and open types. In a closed circuit transformer for a frequency of say, 100, the iron is generally at a low induction, that is to say, about 6,000. If the frequency is reduced, the iron is more strongly magnetized, and the loss of energy per cycle increases more than in proportion to the induction, so that the loss of power increases. It is necessary, therefore, to use larger transformers with low frequencies. Low frequencies thus mean expensive and inefficient transformers. Low frequencies also increase the magnetizing current, but in closed circuit transformers this is not a matter of very great importance. Increasing the size and cost of the transformers is not a small matter. Even if ordinary many-coiled dynamos are used, it is far cheaper and better to increase the frequency than to waste power and money in transformers. In any ordinary house transformer system the tranformers cost far more than the dynamos; and, what is more to the point, the cost of the transformer with a reduction of frequency increases much faster than the gain in the dynamos where there is any. In open circuit transformers the increase of size and cost with low frequencies is still more marked, the exciting current being here a more important factor. For open circuit transformers the cost varies nearly inversely as the frequency, so that, by taking a little trouble in designing the dynamo, the cost of transformers can be made very small.

We may turn now to the question of alternating current motors, but it is hardly the time to consider them, for they are still "in the air." When they are developed into a practical shape it is probable that they will be synchronizing machines. In that case the speed will depend on the number of poles and the frequency. It will, of course, be easier to make motors with a few poles, and it is sometimes stated that users will only require slow-speed motors. In direc current work most users prefer to use small motors running at high speeds to paying for large slow-speed machines. In alternating work it will be the same. A small and inexpensive high-speed motor will be preferred to a large slow-speed motor. It must be remembered that, though a low frequency lends itself to slow speeds in motors, to get a given output needs a large, and, therefore, an expensive machine, whether the frequency be high or low. Having regard to all the circumstances of the case, we believe the American frequency of 130 is about the right one, and that low limits, such as 40 or 60, are a mistake. Recently we have seen 20 periods per second proposed. This would be ruinous both to the pocket and to the eyesight. Helmholtz found that the eye could distinguish 25 periods per second This low frequency would probably be unworkable in the dynamos, motors, and especially in the transformers.

* From *Industries*.

The Telephone Industry in the United States.

From a report of the Bell Telephone Company it appears that the number of telephones in service is 512,407, the total length of line is 255,800 miles, or about 10½ times the circumference of the earth.

Power Required to Haul Suburban Passenger Trains.

[This article is reprinted from the editorial pages of the *Railroad Gazette* for the purpose of showing the point of view from which steam railroad people are considering the substitution of the electric for the steam locomotive. While we do not endorse its statements, the tables and diagrams will be found to contain some very valuable information for those who are studying this problem.—Eds.]

The inadequacy of all electric locomotives proposed for heavy and frequent passenger trains—for service such as must be handled on the prominent suburban railroads—has several times been referred to in these columns, and in particular on Nov. 6 last. We have pointed out what seems to be a lack of appreciation on the part of the electric companies and designers of the problem to be solved. We now present some definite information on this subject to show clearly what is needed in an electric motor if it is to do the work now performed by steam locomotives in the service referred to. The data are based on the present operation of the suburban section of the Illinois Central road in Chicago, one of the largest suburban traffic fields in this country.

The large diagram, Fig. 1, gives the number of trains on the line at the most crowded period in the evening—viz., between 5 and 6:20 P. M.—the location of the trains at a given time, and the conditions under which the locomotives would work if the trains were running exactly to the time tables. The diagonal numbers at the top and bottom correspond to the stations on the road. The distances (horizontal) are given in miles. The vertical divisions represent minutes of time. The short breaks in the lines represent the lengths of the stops, which average about 15 seconds when the trains are not too crowded and the trainmen are alert. The trains are composed of from 4 to 16 cars, according to the traffic, and the average number of cars per train during the hours represented by the diagram is six. The diagrams, Figs. 2 to 7, show the velocities of a train between stations on a distance and a time basis; that is to say Figs. 2 to 4 show the velocities at the different seconds of time from the instant of starting, and Figs. 5 to 7 give the velocities at different distances from the starting point.

The horizontal divisions represent feet or seconds of time as the case may be. The vertical divisions represent seconds of time, pull on drawbar in pounds per ton and total horse power required to haul the trains at various speeds.

These diagrams show also the time from starting from a station to the brake application, and the horse power at different points between stations. From these several diagrams we can obtain the total horse power exerted by the locomotives in hauling the trains, locomotives included, on the line at any instant; also the total pull on the front drawbars, taken to include not only the frictional resistance of the train, but that necessary to overcome the inertia of the train.

These data are based on actual speed and indicator diagrams taken from the suburban engines on the road, and are as accurate as necessary to give a perfectly safe basis for esti mating the power needed to run the road by electricity. From these diagrams we have calculated the average and maximum horse power between stations required to pull a train, and the average and maximum horse power required to run all the trains. The results are given in what follows, together with the coal consumed per use h. p. absorbed in hauling the cars and their lading per hour.

Average number of cars per train	6
Maximum number of trains on line at any one time	14
Maximum number of cars on line at any one time	84
Average horse power required between stations to overcome the inertia and the friction of the trains, as shown from the acceleration diagrams	390
Maximum horse power required between stations to overcome the inertia and the friction of the trains, as shown from the acceleration diagrams	510
Average pull on the forward drawbar of the train in pounds, taken as an average of the pull between stations	7,750
Maximum pull on drawbar at starting, pounds	14,000

If all the trains are running exactly according to the large diagram, which accords with the time table, then the following averages and maximums may be deduced:

Average aggregate horse power for all trains on the line	2,600
Maximum horse power for all trains	4,500
Aggregate pull on forward drawbars, average pounds	51,700
Aggregate pull on all forward drawbars, maximum pounds	108,750

If it happens that all trains are running at once, but not necessarily all starting at once, the following is obtained:

Average horse power for all trains	6,720
Maximum horse power for all trains	7,140
Average pull for all forward drawbars, pounds	172,200
Maximum pull for all forward drawbars, pounds	196,000

According to the diagram, Fig. 1, the following are the averages between the hours of 5 and 6:20 P. M.:

Average number of trains on line	12.3
Average number of trains accelerating at one time	6.6
Maximum number of trains accelerating at one time	10.
Average number of horse power hours of work done by each steam locomotive per day	2,145
Average amount of coal used by a steam locomotive in doing 2,145 horse power hours of work, pounds	14,000
Average amount of Illinois coal used per horse power hour, pounds	6.52

These diagrams and tables give exactly what an electric locomotive will have to do in order to duplicate the work now done by steam locomotives. This is outside of all problems of switching, signaling and distribution of power. Of course all those matters are readily settled. Where a railroad company owns its right of way, it is comparatively a simple matter to lay conductors for the electric current, and the switching of the current can be readily done. The whole question about the substitution of electricity for steam is centred around the possibility of getting a motor sufficiently powerful to do the work, and the handling of such powerful currents as would be necessary on a line like the Illinois Central, where a total of 7,000 or 8,000 h. p. is needed.

The business of the Illinois Central is constantly growing. The number of trains will be doubled within the next few years, and the suburban business will be extended further from the terminus. But, of course, more than one electric station could be used to supply the line, and distribution, in itself, is probably not an insurmountable obstacle. The problem that remains to be settled before much enthusiasm can be aroused among steam railroad men is that relating to the possibility of making an electric motor with power equal to that of the steam locomotive. It will be noticed that the average horse power between stations is about 390, while the maximum is 510.

The problem, then, is to construct and maintain an electric locomotive of sufficient weight to haul a train, one capable of evolving from 500 to 800 h. p. More than one motor to a train is practically out of the question. The exigencies of excursion days, when heavier and more numerous trains are run, we will ignore for the present. It now remains for those engineers who make electricity a special study to bring forward their plans and show what they propose to do. As yet they have shown no special evidence of ability to meet the serious problem we have here out lined. Many railroad men have a feeling of confidence that electric motors will some day supplant our steam locomotives, but it is in most cases decidedly indefinite, not to say superficial. This sentiment encourages the electrical inventors, and it is right that it should, but they will need something more tangible if they are to make the desired progress.

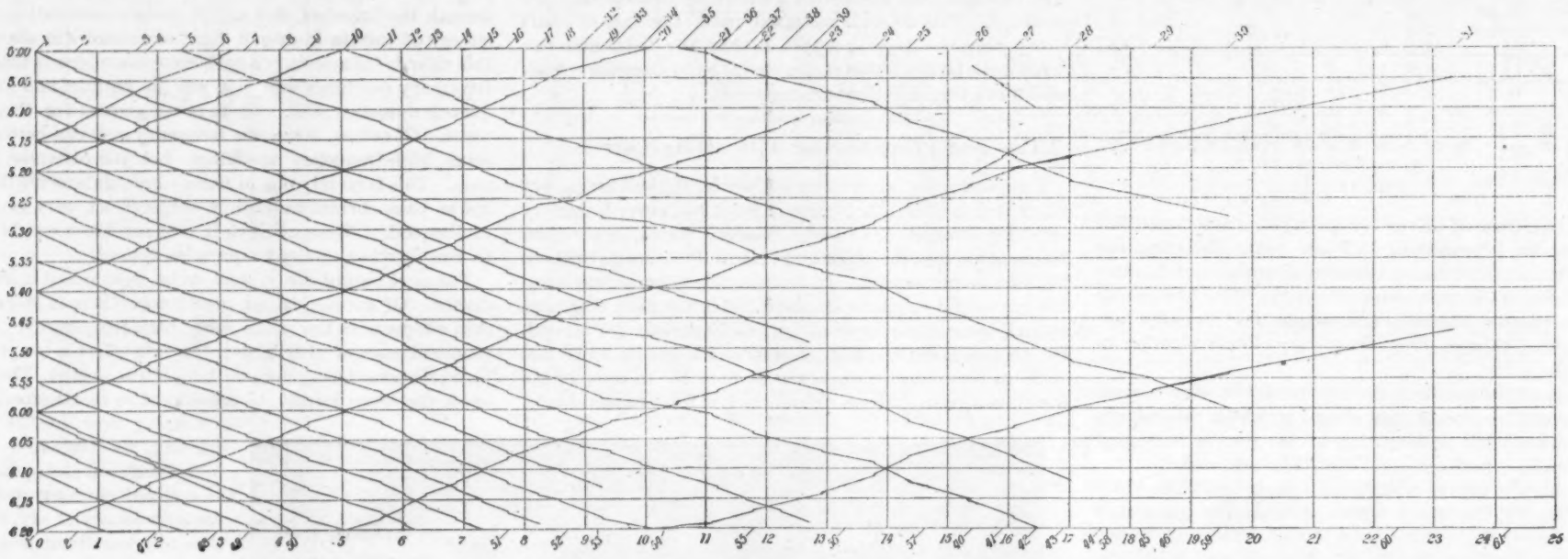


FIG. 1.—TRAIN SHEET OF SUBURBAN TRAINS—ILLINOIS CENTRAL RAILROAD.

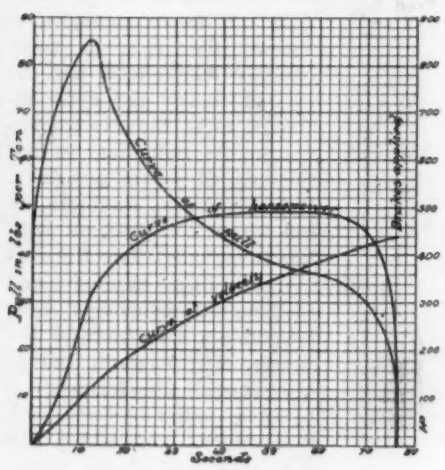


FIG. 2.

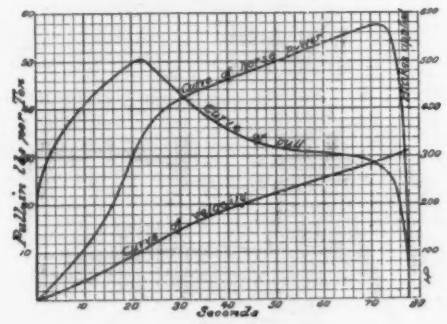


FIG. 4.

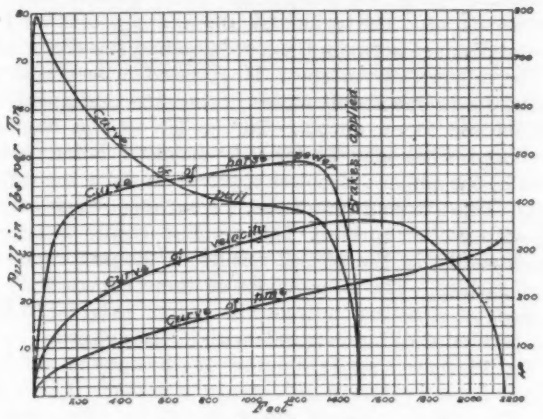


FIG. 6.

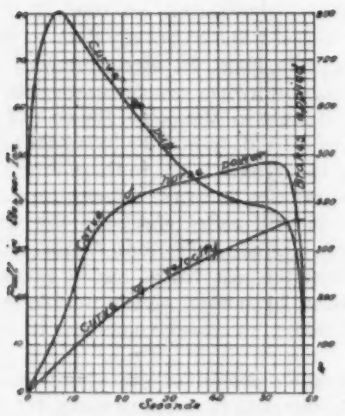


FIG. 3.

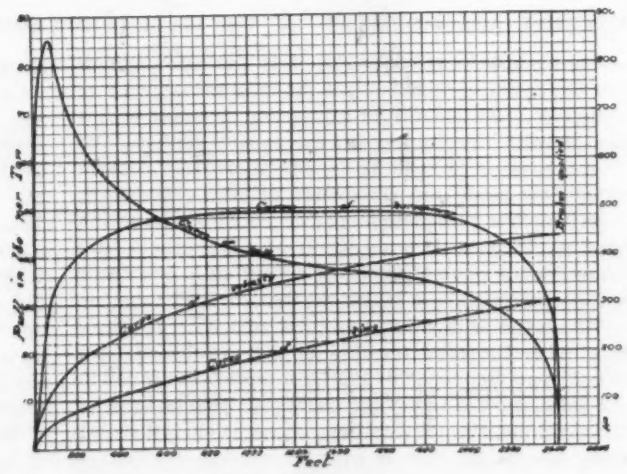


FIG. 5.

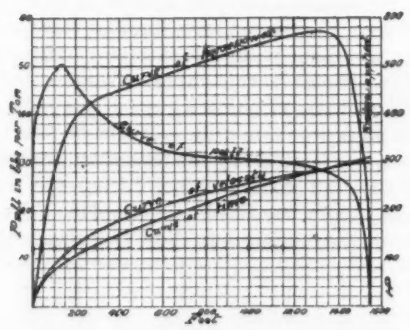


FIG. 7.

POWER REQUIRED TO HAUL SUBURBAN PASSENGER TRAINS.—DIAGRAMS OF SPEEDS AND RESISTANCES.

Coming Development of Electric Railways.*

BY FRANK J. SPRAGUE.

Electric street railways are no longer experimental nor is their success problematical. Their history for the past five years is that of an almost unequaled development. Almost within a decade has occurred the first working of a practical electric railway. In a third of that period there have been put in operation or are under contract more than 450 roads, equipped with nearly 6,000 cars and over 10,000 motors, and with over 3,000 miles of track. There is made a daily mileage of not less than 700,000 miles, and over a billion of passengers are carried annually. At least $75,000,000 have been invested in this industry alone. Thirty thousand horses in a single year have been relieved from the slavery of street car propulsion; stables are disappearing, and streets becoming cleaner; luxurious cars are running on smooth, well-built and rigid roadbeds. Dividends have been increased, expenses reduced, investments enlarged, the unproductive have become productive, the impossible possible. Land values have been increased, habitable limits extended, homes created and time saved. Electric street railway construction has become a matter of engineering, not experiment. Not only have the smaller towns adopted what is the only available means of current supply, but the larger cities are following their example. St. Louis and Baltimore, Minneapolis and St. Paul, Buffalo and Rochester, Boston and Brooklyn have fallen into line, and latterly even Philadelphia seeks an improved street service, and in New York public interest is being aroused.

Among the numerous places in New York where an overhead system could be put in perfect operation are Central Park West, the Boulevard, from Fifty-ninth street up; a part of the First and Second avenue lines, the Third, Sixth and Ninth avenue lines, and all the suburban extensions from the annexed district.

The construction must be of the very best. The only overhead line allowed should be a contact wire with sufficient strength; the main conductors and the feeders should be put underground in proper conduits. There would then be overhead only a wire necessary for the smallest duty and of the requisite strength. In many streets, of course, the cable will hold its own until an electric conduit or surface contact system shall be proven satisfactory.

Impressed by the great development of this industry, and brought face to face with the changes it has wrought, the query is continually made: Will the electric motor replace the steam locomotive? It is similar to the older questions: Will the telephone replace the telegraph? Will the electric light annihilate the gas system? And, in all soberness, a like answer can be made: It will not; but it will, as the electric light and as the telephone have done, create a field of its own, and will replace a portion of the service now done by steam.

It seems to me that the growth of electric railways will proceed something in this order: First, the street systems in the various towns, then connecting lines between adjacent towns following the lines of highways; then longer connecting lines, either on the tracks of existing steam lines, or, growing bolder, on exclusive rights of way on the same order. Then will come suburban traffic on a larger scale, and freight transfer systems, and finally the more ambitious projects of trunk line service under limiting conditions.

It has been very properly said that a man will make the first long rides on electric railway by transferring from one town system to another through connecting links, rather than on individual roads. This is precisely the process by which great steam systems have been built up, although of course starting on a larger scale, and it is but natural that this shall be one step in the development of electric railways.

No one will question the capacity of a motor to do the necessary work required, or to make a speed superior to that of the steam locomotive provided sufficient energy be delivered to its terminals, but we must deal with existing or probable methods of supply. It is true that the speed at which a train is propelled by steam has only increased about 50 per cent. in 60 years, for in 1832 the "Matthew Baldwin" often made a speed of a mile in a minute. But we must not confound speed with power, for while the maximum speed has not been so materially increased, the endurance, the perfection of the mechanism, the economy of performance have made great strides, the increased speed, which is by no means the maximum possible of a locomotive *per se*, has been attained at much higher powers, and the schedule time has been shortened principally by cutting down grades, straightening curves, filling up ravines, abolishing trestle works, replacing wooden bridges by permanent ones of iron or stone; by the use of heavier and stiffer rails, better switches, improved methods of automatic signaling, the interlocking switch and signal system and the abolition of grade crossings; in short, by improvements in details and management which permit of higher speeds on more extended sections of road because of greater safety, lower traction coefficients, and a greater degree of confidence possessed in the engine.

All these things are necessary for high speed electric railways, and any general improvements that will be of benefit to the latter must necessarily be of service to the former.

Almost every one is familiar with the remarkable run recently made by a Schenectady locomotive hauling a special train on the New York Central Railroad, when the distance of 439½ miles from New York to Bufialo was made at an average speed of nearly 60 miles per hour, and which was the precursor of the Empire State Express, which makes the regular run at an average speed of over 52 miles.

More recently we have accounts of an interesting record made by a well known writer on two runs between New York and Albany, on which a large number of indicator cards were taken.†

On the New Jersey Central Road one schedule time is 36½ miles in 39 minutes, which is made where there are a number of necessary slackings in the speed. On the 13th of May the time was taken of the speed of a Baldwin compound locomotive for a considerable period of time on one of the regular runs. Ten continuous miles were made in 452½ seconds and five were made in 222 seconds. The fastest time taken was 44 seconds, and the slowest noted was 47.

In making these very high speed runs there is not much attempt at maximum economy of coal consumption, the necessity being to generate steam as fast as required by the cylinders; but on taking an average of five trips I find that there was evaporated 7.19 pounds of water per pound of coal used. The total weight of train varied from 213 to 241 tons.

I recently inspected a number of engine sheets, one of which gave the duty of 25 engines. The average total cost per engine mile was 10.85 cents, of which 2.66 was for fuel. The total cost varied from 6.8 to 19.24 cents, and the fuel (wood) from 1.96 to 4.77 cents. On another sheet, giving the performance of 22 engines, the total cost per engine mile was 14.70 cents, of which the fuel cost 4.61. The total cost varied from 8.82 to 27.98 cents, and the fuel cost from 2.04 to 7.48. In still another, that of the performance of 18 engines, the total cost per engine mile was 14.73 cents, of which the fuel (coal) cost 6.62 cents. The total cost varied from 10.04 to 22.52 cents and the fuel cost from 3.82 to 13.84 cents.

In discussing the electric system there is often a confusion of statements with reference to economy. Despite the undoubted fact that the electric motor can probably be run at variable high speeds with less variation of economy than can the steam locomotive, we must not forget that in the latter we are considering the economy of the unit as a whole, not merely of the steam cylinders, but also of the boiler and the furnace. In electric propulsion a similar comparison of economies must take into account the variable duty of the central station and the losses on the line as well as those in the motor, and where single units are used the variation in economy of the whole system would be much greater than in the steam locomotive. There will be only a reasonably fixed efficiency of the central station and the line when the number of units is large enough to make the load on the central stations nearly constant.

Some time ago I made a very careful analysis of the work done on the elevated roads in New York City with a view of determining the coal consumption and the duty performed by the locomotives. At the time this investigation was made, now nearly seven years ago, there were in use on the Third avenue division 63 trains at one time running at very close intervals. The weight of the trains was from 80 to 90 tons; the speed was often as high as 20 to 25 miles an hour; stops were made every third of a mile; in short, the duty demanded of the engines was exceedingly severe. The maximum indicated horse power of the locomotives was found to average about 163 h. p., although on occasions these locomotive have been worked up to 185 h. p. Work was divided approximately as follows: Acceleration in starting, 59 per cent.; lifting, 24.3 per cent., and traction, 16.7. The average horse power exerted was 70.3 h. p., considerably less than one-half of the maximum.

The work on the line was so distributed that there was an almost constant total duty of about 4,500 h. p. The locomotives were on duty 20 hours, but used steam only six hours, and including all losses when standing still and the amount of steam used in braking, there was a horse power developed for about 6.2 pounds of coal per hour. I believe that these figures are entirely reliable, and they show a remarkable performance when we consider the class of duty.

An analysis of the coal expenditures showed that, with an efficiency of 60 per cent. and without any of the energy of the train being returned to the line, the relative coal expenditures between steam and electricity would be about in a ratio of two to one; but if the energy of the train was returned to the line to the extent which I believe it is possible, then the relative expenditures of fuel would be in the proportion of seven to two. Since the coal charge on the four divisions was at that time about $550,000, it can easily be seen that, independent of any question of saving in the care of the structure, and any reduction of depreciation of the motor equipment, the fuel saving would be sufficient to pay a good interest on the cost of an electric equipment.

In discussing high speed possibilities and limitations, the testimony of Dr. Dudley, as given in a discussion of a paper before this Institute on the 24th of February, 1891, is interesting.*

Such a shape can be given to the front of an electric locomotive as will make the air resistance not over one-half that presented by a plain surface of equal cross section and perpendicular to the line of motion, but even this fact does not alter the other, that the resistance per ton must be higher for small trains than for large ones.

Speed, capacity and coal economy are, however, not the only questions to be considered in railroad operation, and in discussing the general subject it will be found that the signaling and braking questions at high speeds are serious ones. Undoubtedly an electric train with distributed motors making the weight of the train available for traction, could by using the motors as dynamos to return the energy of the train to the line from the highest to mean speeds and then on a local circuit be more quickly and effectually slowed down and stopped than where shoe brakes are used, and both methods of course would be available. But if using a motor ahead of a train then there will be comparatively little difference in the stopping power.

When riding at 60 or 70 miles an hour, it is a very quick stop to bring a train at rest in less than 2,000 feet. This is often as far as any signal can be made out, especially when the weather is at all thick. Hence we may expect to find on electric railroads, if high speeds are to be attained, and quite possibly also on steam railroads, an extension of automatic signaling, so that trains indicate on more than two sets of signals. At present the practice is to divide the line into sections, and when a train passes a certain point it sets a danger and a cautionary signal, dropping the danger signal on the section just preceding, and the cautionary signal on the one beyond.

Turning now to the greater powers, we must not confuse the terms "large powered" and "trunk line" work. There are two statements which I think will need no corroboration. If we had a continuous train movement completely occupying a track system, there can be no question but that its operation from a central source by electricity would be more economical than if operated by steam locomotives. So too, if a large number of units in reasonable proximity are moved, and the stopping and starting so regulated that the total demand upon the central stations is fairly continuous and equal, then there is no question as to the economy of electric propulsion as compared with steam. On the other hand, the operation of a single or very few units over a long distance would be so uneconomical and afford so small a return on the investment required as to make it prohibitory.

Between these two lies the condition of operation where steam and electricity meet on planes of equality. As the number of trains decreases, steam operation is the more economical; as the number increases electricity must be preferred.

In discussing the use of electricity instead of steam, a well known steam engineer recently stated that in his judgment it must be conceded that electromotive force for the propulsion of cars will not be economical except for suburban traffic and upon certain sections of important trunk lines like the New York Central between New York and Albany, the Pennsylvania system between New York and Philadelphia, the other lines of like character where it is necessary to dispatch a large number of comparatively light trains every day, and at short intervals. The principal field for a power of this kind would be in suburban service long enough to make the ordinary street electric cars unpopular because of the time required; and also in such cases as these mentioned above, for moving freight trains in cities, that is, for the performance of transfer service.

This is precisely in line with the arguments which I have advanced from time to time, and which I illustrated in a paper before the National Electric Light Association and its convention in Kansas City, where I outlined the possible service between New York and Philadelphia, which I believed to be practicable.*

I must repeat that it narrows itself down to the one question as to the number of trains operated between two terminal points. Make that number of trains sufficiently large, and the electric motor is the best means of propulsion whether for high or low speed, whether for large or for small cars. Decrease this number and we must rely on steam propulsion.

Of course I do not in this general reply consider those special cases where advantages are to be gained for which there is a return for capital in another direction. Such a case is that of the Baltimore tunnel, where the investment and cost of operation will be greater than that for steam propulsion; in fact, there will practically be no economy in power because the steam locomotives are not done away with, but are simply unused for a period of little over a mile. There is in this specific case, however, the incidental advantage of doing away with the necessity of a ventilating plant, and yet getting rid of the annoyances incidental to tunnel service.

Every system has its limitation. The electric is not exempt from this law, and hence it will be well to set forth what are well known limiting laws concerning the transmission of energy. They have been stated time and again, but somehow or another people often lose sight of them in discussing the question of investments in large electric railways, so that I think it would be well perhaps to restate and emphasize them:

The weight of copper necessary to transmit a given amount of power with a fixed loss will vary inversely as the square of the electromotive force used.

The distances to which it can be transmitted with a given weight of conductor will vary directly as the pressure.

The distance to which it can be transmitted over a conductor with a given cross section will vary directly as the pressure.

The weight of copper necessary where the supply station is in the centre of a system is only one-quarter that required if the station is at one end.

The weight of copper will vary inversely as the square of the number of supplying stations properly placed.

The electromotive force required will vary inversely as the number of stations.

Lack of knowledge of these simple and unalterable laws has led to much misconception of electrical possibilities, and these have not been confined to the electrical engineers.

Leaving out of present consideration trunk line work, there are three problems requiring solution in the application of electricity to propulsion on a large scale under conditions existing, for example, in Chicago or in any other place where there is a movement of a large number of trains or more or less complicated tracks as will be found at almost all terminal railway stations. They are:

First, the development of an electric locomotive of ample power which shall be as readily controlled as the steam locomotive, shall be reliable in operation, and shall show a high economy. Of course such a machine must have all the adjuncts which are necessary for train movement.

Second, a system of conductor and methods of supporting the same which can be relied upon for ample supply of current and absolute certainty of continuous contact at all speeds on curves, switches, cross-overs and the multitudinous combinations which exist on yard tracks.

Third, a system of automatic block signaling, which, while effective for steam traffic, will not be thrown out of operation by the use of tracks as conductors of electricity for a general supply. This is a more serious question than it is at first considered, for this use will materially interfere with, if not absolutely destroy, the utility of what is known as the rail circuit system. This third problem is one which must necessarily follow the development of the other two, as the automatic signaling systems now existing have followed the development of steam practice.

It will probably be found necessary to erect a variety of conductors. From the most careful consideration which I have been able to give to the subject, I believe there is one way and only one way in which the current can properly be supplied in any complicated system, and that is from the overhead conductor, practically rigid in character, following very nearly the centre line of all tracks and switches, with no movable overhead parts, and with return through the rail. The locomotive would then practically be moving between two electric planes, the lower being the guiding one.

I know there has been a great deal of talk about other possible systems of supply. We have heard much of the charged rail using low potential currents supplied a frequent intervals by motor generators driven from a central station. Since we have discovered no conductors devoid of resistance, and the art of welding is not particularly applicable for railway service where moving contacts are a necessity, little credence need be given to any scheme of this character.

Intimately connected with the question of conductors, and one of the most serious ones which has to be met by the electrician, is that of potential.

For the present, and I think for a long time to come, we must confine ourselves to the consideration of railroad problems where continucus currents are used, and where the traffic between two points is sufficiently large to justify the investment in central stations and conductors which would be required for the operation of such a system.

There are two methods of propelling trains electrically, one by following steam practice—that is, by building a large motor and hooking it to the head of a train, the weight of the motor being such as is required for the necessary power and traction when grades or slippery tracks are encountered. From all that has been developed up to the present to get the control that is necessary and

*Abstract of an address before the American Institute of Electrical Engineers.

† For a full description of Mr. Sinclair's tests on the Empire State Express here referred to, see the article on "The Efficiency of Steam Locomotives at High Speed," elsewhere in this issue.

* For a full report of Dr. Dudley's discussion on this subject see THE ELECTRICAL WORLD of March 21, 1891.

* For the full text of Mr. Sprague's paper before the National Electric Light Association, see THE ELECTRICAL WORLD of Feb. 22, 1890.

to build the machines safely, the electric locomotive will weigh nearly as much per horse power as the steam locomotive. This weight can be better distributed, but I do not think if steam practice is followed on trunk line service that there could be any very material reduction of weight of train.

The other plan is to have each car propelled by one or more motors. This would be the ideal system so far as propulsion goes, provided the electric motor was unlike all other mechanical apparatus, and that it never failed, and if a number of machines could be as well taken care of, cost no more and show as little depreciation as fewer machines of larger capacity operated as a unit.

Should we ever be, as we all hope, in possession of a single circuit alternate current motor, then in view of the simplicity of its control, we may fairly hope for the distributed motor system. But here also the capacity and likewise the weight of the motor being determined by the total duty done, the weight of train limit would not be decreased, but rather increased.

If, on the other hand, single units are used, the query naturally arises, what form would the electric locomotive of the future take? I do not think this is by any means settled. Undoubtedly gearless machines will be used, but whether they will be mounted directly upon the axle, or whether they will movably inclose the axle and be flexibly connected to it while their weight is carried on springs on the truck, or whether the motor will be carried on the truck frame and connected to the drivers by the ordinary coupling rods, are questions which will be determined eventually by the depreciation per car mile upon the motors, trucks and roadbed as well as by the speed to be attained.

Among the roads which are ripe for the electrical engineer, and on which in the near future I hope he will demonstrate he has a most legitimate claim, are the New York Elevated and Chicago Elevated roads, the handling of trains on the New York Central and Harlem roads below the Harlem River, the long talked-of rapid transit road of New York, the Metropolitan underground road of London, the proposed tunnel roads in London, Paris and Berlin, and coming more immediately home, suburban service such as that of the Illinois Central Railroad, a most ideal track for the electrical engineer, and last, and as it will prove one of the most important, the operation of terminal and warehouse systems for the interchange of freight on the lines entering a city situated as is Chicago.

There will probably be in operation in the United States within twelve months not less than five locomotives varying from 700 to 1,209 h. p. and from 45 to 80 tons in weight. The character of the work done will vary. In that work which I am most concerned from a personal standpoint, a 700-h. p. electric locomotive will be built for experimental work, and to attempt to solve as far as may be the various problems which are involved in railroad practice in Chicago. If my judgment is followed, there will be an experimental section of track in the form of a loop about thirteen miles long with eighteen miles of rail, and with every variety of single and double track construction and simple and compound crossings and switches.

On this I hope to see erected such varieties of overhead construction as may be found best to meet the various kinds of service, and where the railroad problems on track jointly operated by steam and electricity can be developed in the most satisfactory manner. On this track there will be not only this locomotive but also one of equal rated capacity supplied by one of the larger manufacturing companies.

The duty demanded of these machines will be severe. They will be required to haul a train of not less than 450 tons at 30 miles an hour up a grade of 26 feet to a mile. They will probably be required to develop their full capacity at all speeds between 30 and 60 miles per hour, and if there is sufficient track room they will be driven at speeds of at least 75 and perhaps 100 miles per hour for short distances. The potentials used will be nearly double that at present obtaining in street railway practice.

A still larger problem, so far as power goes, although not in the variety of conditions which will have to be met, will be that recently taken for the operation of the belt line tunnel now being constructed in Baltimore to avoid the necessity of boat transfer to Locust Point. The duty of the motor here will be to propel the train with engines coupled on but not in operation through a tunnel about 6,000 feet long.

The conditions require the motors, which will weigh about 80 tons and have a capacity of about 1,200-h. p., to propel a 1,200-ton freight train up a grade of 42 feet to the mile at a speed of 15 miles per hour. Passenger trains of 450 tons weight must be regularly started from rest twice in the tunnel on this grade, and in an emergency the motors must start the freight train. The drawbar pull under regular duty, and when not starting, may be as high as 32,000 pounds.

Perhaps the traffic from New York to Philadelphia affords as good an example as any of what may be done on regular passenger service, provided the track is clear enough.

For this I some three years ago,* and again in *The Forum* of September, 1891, outlined an electric express service, with a method of supply through a rod carried above the car and a return circuit through the rails and earth.

All this is said in no spirit of discouragement, for I yield to no man in my confidence in the future of electric traction. No new field is so rich, none more pregnant with great possibilities, but the growth of the work will be more expeditious and healthy if we separate the visionary from the real, the impracticable from the practicable.

A New System of Electric Propulsion.†

BY H. WARD LEONARD.

In the distribution of electricity from a power station for the operation of electric railways the only commercial method to-day is by the use of a system of constant E. M. F. operating the motors in multiple arc with each other, and at the present time every consideration of economy and automatic regulation seems to indicate that the constant E. M. F. multiple arc system will always be the best for such distributions.

In the use of electric energy by motors operating under conditions of varying speed and torque the best results as regards economy and regulation are obtained when the electric energy utilized has a voltage varying directly as the speed and a current varying directly as the torque, for it is evident that under these conditions the electric energy required will be always proportional to the power developed.

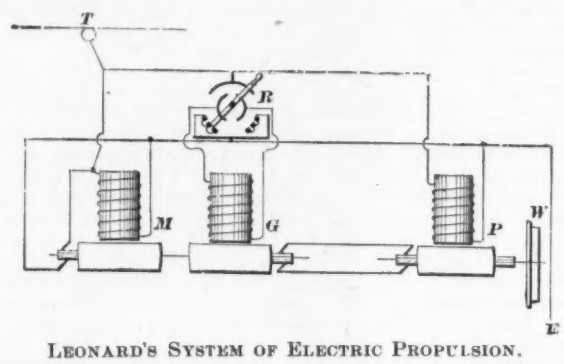
If we could operate from the constant potential system a shunt wound motor running at a constant speed, and could interpose between this motor and the axle some device equivalent in its effect to an infinite number of different sets of mechanical gears, so that we could make use of any reduction desired, it would enable us while using a constant power to increase the torque as we decreased the speed, and *vice versa*, which is just what is desired in railway practice, where the least torque is required when at full speed on the level, and the greatest torque is required at the slow speed in starting and in operating on a grade. Numerous and very ingenious devices have been invented for accomplishing this variable mechanical reduction, but on account of the complication, noise and unreliability they have never proved successful.

The writer has recently devised an electrical method of securing all the results which could be obtained from such a set of gears described, with freedom from the noise, wear, complication and rigidity which such a set of gears would necessarily involve.

Following is a general description of the arrangement proposed, as indicated by Fig. 1:

Each axle is driven by a gearless motor, either directly or by means of a connecting rod. The fields of these motors are excited directly from the constant E. M. F. of the line and independently of the armature circuit. Beneath the car and between the axles there is suspended a motor generator, each armature winding being in a separate field. The motor portion of the motor generator—which will, for convenience, be called the power converter—is shunt wound and connected just as a shunt motor is for use upon ordinary constant potential circuits. The field of the generator portion of the power converter has its field connected across the line and has inserted in it a regulating and reversing field rheostat. This field circuit is independent of the armature circuit. The generating armature of the power converter is in metallic connection with the armatures of the gearless propelling motors. It will be noticed that this circuit including the armature is a distinct and separate metallic circuit having no connection with the line in any way.

Suppose now that our shunt motor is running at full speed and that our controlling rheostat in the generator field circuit is at its central position, so that the generator field circuit is broken. Although the generator armature is being driven at full speed it is revolving in a field having no magnetism except the residual magnetism, and hence produces practically no volts. Let us now move our controlling switch so as to place the generator field across the line, but with a resistance in series with the field, of ten times the resistance of the field coils. We now get a



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slight excitation of the field and a development of volts at the brushes of perhaps 40 volts. This voltage will produce a current through the armatures of the driving motors dependent upon the ohmic resistance of this circuit only; and hence, even at this low voltage, a large current will be produced, which being in a field of full strength will cause a torque sufficient to start the armature. The speed of the armature will, of course, be governed by the counter E. M. F. which its revolution produces in its strong field; and hence, just as in the case of a shunt wound motor, its speed will be practically constant so long as the E. M. F supplied is constant.

If we now gradually increase the magnetic field of the generator by cutting out resistance by moving the controlling switch, we will gradually raise the E. M. F. of the armature circuit, and with it the speed of the driving motors. Since these armatures are revolving in a constant field, the torque they produce will be exactly proportional to the current in them, and the current will automatically flow exactly as is required to produce the necessary torque to maintain a speed such that the counter E. M. F. will approximately equal the E. M. F. supplied by the power converter. Thus it will be seen that the speed of the car will be dependent upon and proportional to the E. M. F. supplied by the power converter, and the torque or tractive effort will be dependent upon and proportional to the current supplied by the power converter.

Let us suppose that 60 ampères flowing through the armatures in fully excited fields will produce a torque sufficient to move the load when upon a grade. It is evident from what we have seen that 40 volts from the power converter will produce this current. Hence, by an expenditure of 2,400 watts in the secondary circuit, or a total power, including field excitation, etc., of about eight horse power, we can start a fully loaded car upon a grade.

Under the existing systems we would need the same 60 ampères in the same fully excited field, but would necessarily use the full voltage of 500 volts, and, therefore, consume energy represented by 30,000 watts, as against, possiby, 6,000 in this system. The current from the line in starting the car under ordinary conditions by this system would be about 12 ampères at 500 volts, instead of from 60 to 100 ampères at 500 volts.

In practice the controlling switch lever can be instantly thrown from its central position to its extreme position for full speed. The field magnetism of the generator is rapidly increased, and consequently also its E. M. F., which in turn causes a gradual acceleration of the car.

The current in the armature circuit, and consequently the torque, is quite large in the beginning, but the E. M. F. at this time is quite low, so that the total watts are low; as the inertia is overcome and the counter E. M. F. begins to approximate to the impressed E. M. F. the current falls off and finally becomes constant at an amount necessary to produce the torque required to maintain the speed. The current from the line, and hence the power, gradually increases from zero to the amount required at full speed, but at no time, either at the start or during the acceleration, is the energy from the line greater than that required when we are operating at full speed. It will be noticed that the effect is the same as though we first operated through a set of gear wheels, giving an extremely great reduction of speed and then rapidly changed the ratio of gearing, until finally we operated at full speed, with no reduction.

With our hypothetical gears we could, when running at speed, rapidly increase the ratio of gearing so that the movement of the car would tend to drive the shunt motor faster and faster. This would convert it into a generator forcing current back into the system, which production of electrical energy would act as a brake and gradually bring the car to rest.

Just so, if, while running at full speed, we suddenly place our switch lever at its central position, the field of the generator will gradually reduce the strength and the counter E. M. F. of the propelling motors will soon exceed that of the generator. The momentum of the car will now be driving our gearless motors as generators, which will supply current to the former generator, operating it as a motor, causing it to drive the shunt motor coupled to it as a generator, which, in supplying energy to the line, will act as a brake, and smoothly but rapidly bring the car to rest by converting the energy stored up and represented in the movement of the car into electrical energy, which will tend to relieve the work at the central station. Similarly, a car descending a grade and tending to accelerate in speed can be made to move at any desired speed without the aid of any mechanical brakes, and the energy represented by its falling weight will be converted into electric energy and the car will become a moving feeder supplying energy to assist the generators at the central station in the operation of other cars.

It will be evident from what has preceded that with this power converter system we can propel a car upon any practicable grade with a consumption of power no greater than is required to operate the car at full speed upon a level, by merely reducing the speed to the required extent.

In street railways of from five to ten cars, this is of great importance, for it means that we can equip a road with about six horse power per car, as regards the engines and dynamos, and that our conductors can be reduced to about one-third of the amount at present neces ary, for we will never require more than 20 ampères at the distant point, where to-day we have to provide for 60 ampères with the same loss and same initial E. M. F.

Under the rheostat system the plant is severely taxed when an unusual crowd must be moved from a certain point, and it is then, when it is of the greatest importance that no break-down should occur, that it usually does occur. With this power converter system we could, upon a five-car road, start up and move with perfect safety 10 or even 20 cars to the most distant point on the road, though of course at a reduced speed, but the crowd would be handled with perfect success and without subjecting any portion of the plant to any unusual strain.

In the large cities it is no unusual sight to see an electric car moving at the slowest possible speed for perhaps several blocks. Perhaps 12 ampères are required to obtain the necessary torque. This at 500 volts is 6,000 watts. The power required for this slow motion by the proposed system would not exceed one-fifth of this amount.

Following is a tabulated statement (Table 1) showing the results we may expect to obtain by this system in operating with fully loaded car under three different conditions: First, at 12 miles per hour on level; second, at three miles per hour on five per cent. grade, and third, at one and one quarter miles per hour on a level.

Table I.

Duty of Car, Showing Various Losses Expressed in Watts.

Various Losses Involved.	Eight tons at 12 miles per hour on level. Full speed, 1-6 full torque; armature current, 10 ampères.			Eight tons at three miles (or five tons at five miles) per hour on five per cent. grade. One-quarter full speed, full torque; armature current, 60 ampères.			Eight tons at one and one-quarter miles per hour on level. One-tenth full speed, one-sixth full torque; armature current, 10 ampères.		
	Power converter.		Driving motors.	Power converter.		Driving motors.	Power converter.		Driving motors.
	Motor part.	Gen. part.		Motor part.	Gen. part.		Motor part.	Gen. part.	
Field	250	275	250	250	60	250	250	25	250
$C^2 R$ in armature ...	160	60	60	250	2,000	2,000	20	60	60
Friction.....	60	60	120	60	60	30	60	30	10
Foucault currents, hysteresis, etc.....	200	400	400	200	50	50	200	10	10
Total.....	670	795	830	760	2,170	2,330	530	125	330
Total watts wasted....	2,295			5,260			985		
Watts of work done	4,000			6,000			400		
Total watts absorbed	6,295			11,260			1,385		
Ampères at 500 v..	12.6			22.5			2.8		

In arriving at the losses, as indicated, the motor part of the power converter has been assumed as having the following features:

E. M. F. 500 volts, current capacity for 10 hours' continuous duty, 15 ampères; resistance of shunt field winding, 1,000 ohms, armature resistance, 1.1 ohms.

The generator proportion of the power converter and the driving motor are assumed as having the following features:

E. M. F., 500 volts; current capacity for 10 hours' continuous duty, 40 ampères; resistance of field, 900 ohms; armature resistance, 0.55 ohm.

The rolling friction with gearless motors on good level track is assumed as 20 pounds per ton. Car is assumed to be eight tons in weight full loaded, and five tons for moderate load.

We find that with 12 tons moving at 12 miles per hour on a level we will require 12.6 ampères, which is practically the same as by present series motor systems. With eight tons moving at three miles per hour upon a five per cent.

* See The Electrical World of Feb. 22, 1890, for a full outline of this plan.

† A paper read before the American Institute of Electrical Engineers.

grade 22.5 ampères will be required, which is about one-third of the power required by present systems. With eight tons at one mile per hour on a level 2.8 ampères will be required, which is about one-fifth of that required by present systems. With five tons moving at five miles per hour on five per cent. grade 18.5 ampères will be required, which is about 40 per cent. of the power required by present systems.

Let us examine some of the advantages that this method seems to offer over the existing methods, starting at the car and considering the entire equipment back to the boiler.

In order to place before you the opinions of some of the best authorities on the questions involved, I shall quote freely from "The Electric Railway," Crosby and Bell; Parshall's "Methods of Electrically Controlling Street Car Motors;" "Comparative Test of High and Low Speed Engines in Electric Railway Work," by Charles W. Wason (*Electrical Engineer*, April 27, 1892); "The Practical Operation of the Gearless Motor," by S. H. Short (THE ELECTRICAL WORLD, April 16, 1892); "Load Diagrams of Electric Tramways and the Cost of Electric Traction," by A. Reckenzaun (*Electrical Review*, London, March 25, 1892).

The cost of car equipment will be increased by the cost of the motor generator, but as a partial offset to this we have saved the rheostats, two expensive controlling switches and a complex system of wiring.

Our motors, having constant and fully excited fields, will operate absolutely without spark under all conditions. The control of the car will be entirely accomplished by a small switch and rheostat, handling never more than one-half of an ampère and occupying a space of one foot square and one inch deep over all.

As regards efficiency, we will have the advantages of the present system under all conditions. For long runs upon the level we will, by a suitable switch, connect the driving motors directly to the line and secure an efficiency of 90 per cent. for our motor.

As regards depreciation, we will have the advantage of no rheostats or controlling switches to burn out, and with no sparking and no connection with the field circuit we will have the minimum liability of burning out armatures. Our fields will have no tendency to burn out, since they are not subject to the excessive currents which the present series fields are. The current in our fields will be independent of the load.

As to field windings and rheostats in existing methods, Parshall says:

"With 25 h. p. motors an external resistance of 10 to 12 ohms is required.

"Lessening the duty of the rheostat is a very important point, since as yet it has been found exceedingly difficult to construct a cheap rheostat that could be placed under the car in the small space available and dissipate so large an amount of energy as is required when the car is to be run for a considerable time at a speed so low as two or three miles an hour. Any method of control that has lessened the energy to be dissipated in the rheostat has in general been considered with favor, since there has been a corresponding diminution of trouble in each case that the energy to be dissipated has been lessened.

"The range of speed without the use of a rheostat is determined by the limit to which it is safe to heat the magnets."

Crosby and Bell say:

"In using this method (commutated fields) the principal difficulty has been met with in disposing of the excessive heat necessarily generated in the compact mass of field windings.

"The practical problem has been to secure a convenient rheostat.

"The principal sources of loss in our present street railway motors are the regulating devices and the gearing.

"With the motors and the gearing generally employed, the average commercial effciency of the combination is probably not often in excess of 65 per cent., giving a total commercial efficiency for the system, from engine to car wheel, of 39 per cent.; this of course is but an estimate. But taking all the factors into consideration, it is probable that the average of the roads now in operation would fall quite nearly to the point indicated. In very few cases would it fall below 30 per cent.; in still fewer would it rise above 40 per cent."

Regarding the power required to start a car on existing methods and to operate it upon level and grades, Crosby and Bell say:

"With the ordinary car equipment of two 15-h. p. motors, and the usual speeds, from 8 to 12 miles per hour, experience has shown that five to six electrical horse power is necessary on nearly level tracks.

"The amount of current ordinarily taken in starting a car is momentarily more than 50 ampères, which at the ordinary voltage corresponds to about 25,000 watts."

Reckenzaun says:

"If we calculate from the accepted coefficients of resistance to traction on common tram rails, we find that an ordinary tram car will require but three to four horse power for its propulsion when once in motion."

He says of Thomson-Houston car:

"The maximum current at any time was 75 ampères."

Of Sprague motors:

"Here again we observe a maximum current of 75 ampères."

Westinghouse motors: "Maximum current 95 ampères."

Short finds that 80 to 100 ampères are required to start a car and says:

"On this road the traffic is very heavy, although grades are light."

Leaving the car, let us now consider the line. It will be evident from what we have seen that we can reduce the amount of copper to one-half the present requirements, as we never will require the enormous currents at present called for in starting and upon heavy grades. Or, to put it in another way, with the existing conductors we could run twice as many cars as at present, with the same loss in the conductors.

Now, let us look at the generators and the prime movers, whether steam engines or water wheels.

Under existing systems for roads of from five to ten cars, it is necessary to install about 20 indicated horse power (rated at about ¼ cut-off) per car and about 16 kilowatts per car in generators. Also about 20 h. p. per car in boiler capacity. This large equipment is necessitated by the occasionally very large demands for power and the inefficiency consequent upon this.

Under the proposed system it is not necessary to provide power in excess of 15 h. p. for any car under any conditions, and since in practice most of the cars will be operating at less power than this, we need only install engine, dynamo and boiler capacity of eight horse power per car instead of 20. Or, to express it another way, we can operate with existing boilers, engines and dynamos at least double the number of cars they can at present supply.

Crosby and Bell recommend, for a five-car road:

"An equipment consisting of two 40,000 watt dynamos, one 80 h. p. high-speed simple engine belted directly to them, and two boilers of about 50 nominal horse power each."

Now, let us look at the economy of the operation of the station. With the extremely fluctuating loads of existing systems, the economy of the entire generating plant is very low. The stations of three roads which have been tested give for the combined efficiency of engine and dynamo 40 per cent., 54.6 per cent. and 62.8 per cent. respectively. If the load can be kept approximately constant, the combined efficiency of engine and generator should be about 75 per cent., and in the proposed system the load will be sufficiently uniform for us to expect an efficiency equal to this, and because of the nearly constant load we can produce a horse power on about 25 pounds of water, while in present practice for small roads about 50 pounds of water per horse power is a fair figure, and the best published result thus far obtained, even when the average horse power rose to 750 h. p., is 28 pounds per horse power, as found by Wason, at Cleveland, in operating a total of 71 motor cars.

With the present systems the average indicated horse power per car is about 12 h. p., which on account of fluctuating load requires at least 36 pounds of water per horse power, or about 420 pounds of water per car per hour.

With the proposed system we will operate with an average of about eight indicated horse power per car, which, on account of the steady load, will be produced with about 25 pounds of water per horse power, or 200 pounds of water per car per hour. That is, we require about 50 pounds of coal per car per hour by present systems, and about 25 pounds of coal per car per hour by the proposed system, or a saving of 50 per cent. in the coal and water required in favor of the proposed system.

On this subject of fluctuating loads and their effect Crosby and Bell say:

"A record of 10 minutes on a recording ammeter may give some faint idea of the condition of things. It will be seen that at one point the output jumped from zero to 150 h. p. and back inside of a single minute, and during the latter five minutes shown in the diagram there were no less than 25 sudden *variations* of 50 to 100 h. p., each taking place within a few seconds. The road from which this record was obtained is four miles in length, and was operating seven cars at the time of the test."

Reckenzaun says:

"These abrupt changes have the effect of reducing the efficiency of the whole system to a comparatively low figure."

Church says (*Electrical Engineer*, April 27, 1892) that the best compound engines will show an economy of only 28 pounds, and the usual compounded engine "an average duty not better than 35 to 40 pounds. The same is true of every form of non-compounded engine, whether high speed or low speed, both of which show a tremendous falling back of fuel duty under variable load."

Let us now examine the comparative first cost of a railway of moderate size, say from five to ten cars equipped by present systems and by the proposed system.

The detailed figures per car are given in Table II.

TABLE II.

Showing probable comparative first cost per car by present and proposed system.

	Present system.	Proposed system.
Steam plant, generators and conductors per car (steam plant 1,000, generators 700, conductors 500)	$2,200	$1,100
Motors (two 15-h. p. equipmen's)	1,800	1,400
Power converter	0	900
Controlling switches, cables, rheostats, etc.	200	30
Total first cost per car	$4,200	$3,430
Saving in favor of proposed system per car		$770

Table III. gives a summary showing the features of the proposed system as compared with the corresponding features of the present system.

TABLE III.

	Present system.	Proposed system.
First cost of steam plant, generators, conductors and car equipment per car	$4,200	$3,430
Ampères at 500 volts required to start full load on level	75	2.8
Ampères at 500 volts for full load at full speed on level	12.5	12.5
Ampères at 500 volts to start full load on 5 per cent grade	125	10
Ampères at 200 volts for working speed on 5 per cent. grade	60	22.5
Ampères fed back to system in coming down 5 per cent. grade	0	10
Pounds of coal per car per hour	50	25

The features of the proposed system which seem, at first sight, to be very objectionable are: The increased cost of the car equipment and the fact that we are adding an additional machine, having two fields, two armatures and three bearings; but, as we have seen, there is only an apparent increase in the first cost, for the saving in the generators and distributing plant far exceeds the additional cost of the car equipment; and the use of the motor generator for elevators, traveling cranes, etc., has demonstrated that, as regards the attention it requires and the depreciation it suffers, it has a marked advantage over the rheostat or commutated field used in the present methods of operation.

Electrical Engineering at the Johns Hopkins University.

The programme for the electrical engineering course at the Johns Hopkins for 1892-93 has recently been issued. The course is intended primarily for graduate students, but special students are admitted after completing the studies of the preparatory year, which include work in mathematics, physics, chemistry and drawing at the University, or upon satisfying the instructors that they have covered the same ground elsewhere. The course extends through two years, and includes instruction in theoretical and applied electricity, steam and hydraulic engineering, machine design, mechanics of engineering and mechanical drawing. An important feature is the laboratory work, and students are expected to give as much time as possible to it. Every encouragement is given to original research.

Near the close of the year the class will conduct a test of a central station and electric railroad and prepare a complete report on the same.

Electro-Technical Education.*

BY R. B. OWENS.

My object in presenting this paper at this time is to induce, if possible, a discussion which will throw more light on the relations which should exist between our profession and other engineering professions, as well as to learn by an interchange of opinion, the best methods of instruction to be adopted in the training of electrical engineers. The subject of the technical training of mechanical engineers has been very fully treated by the Society of Mechanical Engineers, and the transactions of the Institute of Mining Engineers contain valuable suggestions as to methods of training mining engineers, and so with other engineering societies. But as yet the subject of the technical training of electrical engineers has, I think, hardly received the attention it deserves from our society, and in view of the fact that we have well represented all branches of electrical work, both managers of manufacturing companies, members of engineering firms, and a number of men prominent in educational circles, I shall venture to hope the subject will receive the exhaustive treatment it well merits. We can consider ourselves fortunate in having a society such as this, where engineers engaged in every variety of work may meet on common ground and learn from each other, and I might here suggest, if, indeed, it has not been already suggested, that subjects be chosen by a suitable committee and appointed for "Topical Discussion" at certain meetings as the mechanical engineers have done, and in this way still further increase the sphere of our usefulness.

Having stated my reason for presenting this paper, I shall try to show the necessity of making technical training in general, graduate instruction and electro technical training in particular.

A moment's reflection will show that to the man of pure science or to the engineer we owe all our methods of rapid communication and transportation, our supplies of metals and the necessities of daily life, as well as the utilization and adaptation of the latent and wasting powers of nature, but it is difficult to say to which one we owe most. "To have the application of a science we must have the science itself," as remarked by Prof. Rowland in his address before Section B of the American Association in 1883, but how often are the inquiries of such physicists confined to the simple enunciation of a physical or chemical principle which remains practically unproductive of good for centuries, and perhaps has to be discovered again, as witness the work of Lord Henry Cavendish. But I would not depreciate the work of the man who so often foregoes wealth and ease to devote his life to that highest of human efforts, the study of nature's secrets and the enunciation of her laws. His mission is a high one and rarely appreciated as it should be, or else the "lucky inventor who is lauded in every newspaper would not receive more praise than him who, perhaps, discovered the principle upon which the invention is based and died in obscurity and want."† Not that the trained inventor deserves no credit; the world owes him much, but not more than the man of pure science.

Between the scientist and skilled mechanic or handicraftsman is the engineer—the man who, familiar with the results of scientific investigation and methods, uses both, by the help of the mechanic's skill, to minister the more effectively to the wants and will of an ever-increasingly exacting public. To him alone we look for the solution of the problems of transmitting and distributing the power of waterfalls and fuels, the tunneling of our mountains, the building of our railways and steamships, as well as the more delicate work of flashing our thoughts and words from town to town and from continent to continent. This field of work is so vast that of necessity it must be divided among specialists and sub-specialists; but since the "Vril" of Lord Lytton's "Coming Race" has shown itself so marvelously well fitted to do our every bidding, I believe a great portion of the work hereafter will be done by the electrical engineer. And as so much will be expected of him, the duty devolves upon us to give him such training in his youth as will most effectively enable him to grapple with the problems to confront him in his future work. I have said the engineer uses the mechanic's skill in the accomplishment of his aims, and if so, he must possess a certain familiarity with tools and shop method, or else he will not always be using such skill to the best advantage; but evidently it is not expected of every engineer that he spend sufficient time on shop practice to attain the same degree of efficiency in the use of tools as acquired by the mechanic who devotes his whole life to their use without attaining the highest skill in manipulating them. And experience, both at home and abroad, has shown that systematically conducted elementary schools where the "manual element" has been introduced "are far more efficient in developing and training of youth than the best managed mill or shop,"‡ for in the latter, despite the good intention of the manager or president, the learner is kept months by the foreman stamping out armature discs, if there were need of armature discs, or punching holes, if there were need of holes. While in the school the variety of equipment is greater than in the best shop, and every operation is taught with the object of making the student familiar with the principle involved, and no more time is spent on one operation than is sufficient to insure a thorough understanding of it.

Until within the past few years the value of the manual element in education has been sadly overlooked in elementary instruction in this country. Special and distinct schools, called variously Manual Training Schools, Schools of Mechanic Art and Developing Schools, have arisen where those elements which underlie all industrial pursuits have been introduced into general elementary education, not because students leaving such schools expect always to enter upon some trade or into some "Trade School," but because such instruction is eminently "desirable for the roundness and unity of general education, and valuable no matter what the future of those so educated may be."§ The Massachusetts Institute of Technology, the Washington University, St. Louis, and others, have attached to themselves schools of mechanic arts and manual training schools for the reason, I take it, that the elementary public schools do not afford such instruction, and they recognize the great educational value of their training.

But as soon as such instruction is given as it should be in the public or preparatory schools, the universities will find it no longer necessary to devote their energies to such elementary work, but will reserve their whole force for the higher instruction for which they are originally designed.

* Abstract of a paper read before the American Institute of Electrical Engineers.

† Prof. Rowland.

‡ Prof. R. H. Thurston.

§ President J. D. Runkle, "Manual Element in Education."

Aside from the educational value which instruction in the use of tools, wood-turning, pattern making, forging, metal working, etc., has, and which alone would justify it, "simply on the ground of the discipline it gives,"* such instruction becomes of double value to a student intending either to learn a trade or become an engineer. If he intends to learn a trade, and perhaps be a shop foreman, he probably knows, due to the manual instruction already received, whether he will become a watchmaker, carpenter or machinist, and enters a trade school where the technique of his chosen trade is taught.

If his aspirations are higher, he pursues his studies still further and enters a technical school whose primary province is the training of engineers.

In studying the various courses given in the best technical schools in this country and abroad, and the opinions of educators and engineers, I take it that a technical school is primarily a place for the preparation of men who expect to earn their living as engineers. It is not a school of general culture, nor is it a school of abstract science. It is a device to save time, and teaches the applications of pure science to industrial purposes.

A technical school is also, I claim, a post-graduate school in the ordinary sense, and in this respect should rank with schools of law and medicine. If the engineer is a man who uses both the results of science teaching and mechanical skill, he must certainly have great familiarity with both, and the attaining of such familiarity will constitute his undergraduate work. But, after such general knowledge is acquired, no time should be lost in fitting each student to be of the greatest immediate value to those who employ him. Unfortunate as it may be, we must reconcile ourselves to the necessity of becoming specialists. It may be argued that "The more a man knew of all the related branches the better he could perform his special work, but this is only arguing the advantage of omniscience.† Time was when all known about electricity would not greatly tax the ordinary intellect, but now each student can only hope to become an expert in one very narrow department, and I believe we must shape the courses, as far as possible, in our electro-technical schools to meet the requirements of the times.

Of course, to employ a number of specialists and to give each student the opportunity to choose the work he is best fitted for will be expensive, but if our country is to keep apace with others in industrial progress she must educate her engineers. When private generosity fails, State aid must be forthcoming or we will have to witness others surpass us in the race for international position. "It is in consequence" of superior industrial and technical education "that Germany is gaining a better industrial position daily."‡ And the same might be said of several other foreign countries, so that on the score of economy no more profitable expenditure of public money is possible than for the support of technical schools. Education is not a money making business. "No fact is more firmly established all over the world than that higher education can never be made to pay for itself."§ No considerable income can be anticipated from student fees. Higher education must look for its support to private munificence or public help, and, as suggested to the English Institute of Electrical Engineers by Professor Ayrton, it would seem to be the duty of such a body as this to influence as far as possible public opinion in favor of advanced electro-technical education.

Having seen the importance of manual training as a factor in elementary education, and knowing its special value to those intending to become either handicraftsmen or engineers, I would recommend that a fair knowledge of forging and foundry work, pattern making, wood and metal turning, and drawing be required of every student for matriculation into any college course. Such an elementary knowledge can readily be acquired by the average student by the age of 16 or 17, along with the elements of English education, such as given in our high schools and academies.

The importance of drawing can hardly be overestimated. It is rightly called "the shorthand language of modern science," and everyone can learn to draw with a fair degree of accuracy, although the "negative faculty of drawing in some people is almost miraculous."‖ I do not mean artistic drawing, painting and perspective, but the elements of orthogonal projection can be as easily acquired as the art of writing, and for some purposes it is just as useful. Indeed, "drawing is now regarded by many educators as an established factor in elementary education, and destined to work its way into all classes of public schools."¶ At the age of 16 or 17 a boy having had good advantages should be able to enter any of our best American colleges, and here, if he intends becoming an electrical engineer, I would have him study for three years mathematics, chemistry and physics, with German and French. These apparently few subjects will absorb the greater portion of his energy. Nothing is gained by working at excessive pressure in early life; and as to knowing anything about engineering itself, it would seem best to leave that alone until a thoroughly good scientific education had been first acquired. When electrical engineering is taken up in earnest the student should have such a command of physical and chemical facts and methods, and be such a master of mathematical analysis as to leave him free to discuss engineering problems without the necessity of first acquiring the facts and methods he may wish to make use of.

A good course in modern geometry, differential and integral calculus, say according to Williamson, and differential equations, say Forsyth or Craig, would be sufficient to pursue with advantage nearly any course in electrical engineering given in this country at the present time, and when in reading Maxwell it becomes convenient to have quaternions or spherical harmonics, they can be studied in connection with such reading. But to attempt to analyze the action of alternating current apparatus without the use of differential equations, is, to say the least of it, no very easy task. We admit the value of geometrical methods and especially as expressing in convenient form, the result of algebraic analysis. Indeed, in the hands of Mr. Kapp, Mr. Blakesly and a few others, they have been used with excellent analytic effect, but their general weakness as compared with modern methods, is too well known to need comment. As regards the amount of general physics required, I should say the student ought to be familiar with the theory of heat measurements, thermo-dynamics, the principles of fluid motion, the dynamics of a particle, and of solid and rigid bodies, the theory of sound and physical optics, and the facts and principles of magnetic and electric actions. Above all he should be able to apply mathematical reasoning to physical problems and be skilled in the art of experiment.

In ordinary electrical work a knowledge of inorganic chemistry would perhaps suffice, but if one expects to make a specialty of electro-chemistry, then both organic and inorganic chemistry should be required.

Besides mathematics, chemistry and physics, which must be considered as principal subjects of the directly preparatory course, German and French should be acquired, as so large a part of our best electrical literature is in these languages.

Indeed, aside from the three principal subjects of the preparatory course, it would seem best to allow as wide range of choice in the remaining subjects as he is capable of carrying, for engineering is "a narrow life which concerns itself solely with building bridges or making analyses,"* building, erecting and testing electric and magnetic machines. Unless his general education is gotten in early life, I believe it is the experience of engineers that such culture is doubly difficult to attain after entering upon strictly professional duties.

Assuming, however, that a thorough working knowledge of mathematics, physics and chemistry is possessed by the student, then I believe he should spend three years in studying the applications of his acquired facts and principles before attempting to practice his profession.

We must, I think, recognize three classes of electrical engineers in this country at this time: first, the installing engineer, who superintends the equipment of central or isolated electric light or power plants, electric railways, mining plants, etc,, and runs the same when completed. In this class of work more than a knowledge of electricity is required. It becomes essential to have a thorough knowledge of steam engineering, track and pole line construction as well. He should be as well able to choose the best engine and boiler for a given set of conditions, and to install and operate them economically as he is able to choose the best dynamo, motor, line wire or lightning arrester. A practical knowledge of building foundations, laying out railway curves, running pole lines, is to this engineer a matter of greatest importance.

The next distinct class of electrical engineers I would recognize, are designing engineers, who rather have to do with the manufacture of electric apparatus, than its installation. Such men design and superintend the construction of the apparatus put on the market by the several manufacturing firms, but rarely also have to do with steam engines, track construction, or pole lines. To this second class, a correct knowledge of machine design is of equal importance with a knowledge of magnetism and electricity, and it was perhaps of such men that Lord Kelvin was thinking when he said an electrical engineer should be nine-tenths mechanical and one-tenth electrical.

The third-class of engineers are employed by standardizing bureaus, and in laboratories, to make tests of electric and magnetic constants, calibrate instruments, etc. For such work neither a knowledge of pole lines, foundations, or machine design, is so important as familiarity with delicate methods of measurement and skill in manipulating sensitive instruments.

It would seem best then to shape the course in any electro-technical school, as far as possible to meet the requirements of these distinct classes of engineers.

The proportions of the three kinds I have named vary greatly in different parts of the country. With us at the West, the greater part of electrical work consists in installing and operating the apparatus manufactured by Eastern firms. In some few cases electric factories started west of the Mississippi have been successful, but their number is not great, and the proportion successful is less. The time will undoubtedly come when the mineral wealth of the West will be mined and manufactured by Western waterfalls, but so long as the East continues the centre of manufacturing interest, the principal work of the electrical engineer in the West will be installing and operating Eastern manufactured apparatus. Therefore, to meet the immediate home demand for engineers, I believe our Western schools of engineering must make a specialty of training installing engineers. In the East the case is different. More men are employed by manufacturing firms, testing and standardizing bureaus than by construction and engineering companies, so that the course given in the Eastern schools of engineering, and which are largely for the designing engineer, are justified.

After an inspection of the engineering departments of the University of Nebraska some months ago, Prof. R. H. Thurston declared the electrical equipment to be "the finest, considering the size of the institution, in the United States."†

* President Runkle, "Report in Developing Schools."
† T. M. Drown, *Journal Frank. Inst.*
‡ Prof. R. H. Thurston.
§ Prof. Rowland.
‖ Prof. Huxley.
¶ Pres. J. D. Runkle.

The Technical Education of the Electrical Engineer.‡

BY DUGALD C. JACKSON.

Perhaps it would be well to call my subject the "College Education of the Electrical Engineer," for it is strictly of the technical college course that I shall speak. We can truly affirm that the technical education of an engineer does not end until his work is ended, and the college course is but the commencement of it. That the college course can be made a very important fundamental part of this education is becoming more thoroughly appreciated as the work of the technical schools comes into closer harmony with the demands of the profession, and it is now generally agreed that a technical college course, of the proper kind, forms a valuable aid toward the success of the average young man who wishes to enter the engineering professions. It therefore becomes a matter of no little moment to so arrange the course that its usefulness will be a maximum. A few years back a college course entirely devoted to the training of electrical engineers was unknown. At the present time there is no dearth of such courses and their organization is progressing right and left, whence it is well to carefully consider what requirements of the electrical engineer's profession they may be made to meet, in order that no powder be wasted. It is neither possible nor desirable that the courses of study of electrical engineering students in the various schools should be alike, but a certain unity of purpose and treatment should be observed, and all can profit by the suggestions made by the practical man.

With this in view, I present the subject to your attention as it is looked upon at the Engineering School of the University of Wisconsin. There is no originality claimed for the ideas presented, as they are based upon the recorded experience of some of the country's most successful practical men, and are virtually followed in such other engineering schools as make their courses thoroughly practical, and therefore, in the true sense, professional. I trust, however, that a discussion will arise that is in proportion to the wide importance of the subject to the electrical profession, and that must result in a considerable increase in the efficiency of the electrical engineering courses in our various colleges, nearly all of which are still in process of crystallization.

In order to enter the freshman class of the best engineering schools, the applicant must have a thorough common school education, including mathematics through ordinary algebra, a fair knowledge of English, a reading acquaintance with German or French, a little elementary physics and chemistry. This can be gained in the high schools of most of the cities of this country. The high school timber (some of it quite green) the college is required to work, and to work it to the best advantage requires no little careful designing. In order that an engineer may use his abilities and training most advantageously, he should have a good general education, including a fair knowledge of literature, history, economics and certain elements of law. This cannot be expected to come from the high school, and you can readily appreciate that an attempt to give a general education in an engineering course can only result in sacrificing the good of the students by omitting essential fundamentals. Thus, to have an average chance of proving successful, an electrical engineer must be well grounded in three sciences besides those gained in the common schools, and which cannot be classed as engineering. These are: Higher mathematics, as far as it may be practically applied in engineering; chemistry and physics (including elementary electricity and magnetism); and manual training. A few students enter college who have been given a fair start in these, but they are the exception; consequently, the subjects must be taught from the ground up, with a common sense view to their practical applications. Unlimited time could be given to these preparatory subjects, but it is necessary to clear them away in the actual time of two college years. With this requirement it is impossible to give a very thorough knowledge of analytical chemistry, or of physics, but they are taught so as to give the student a good working knowledge and so that he can readily go deeper if he finds it to advantage in his future practical experience. The higher mathematics require all the time that can be afforded, especially in its last division, that of applied mechanics, where the student gets his systematic knowledge of the properties and uses of materials.

With the preparatory studies cleared away the student must enter into professional studies in earnest, but there is little time for true engineering. The developing electrical engineer must expand his physics and his chemistry and mathematics into the laws of electromagnetism, alternating currents, electrolysis and electrometallurgy, and study the conditions of their numerous practical applications in engineering and the arts, each of which may demand months of constant effort before an intelligent mastery is attained. Neither can he confine his attention to these during two full years, for he must gain an elementary but practical knowledge of thermo-dynamics and hydraulics, with an efficient working knowledge of their applications in steam and water power plants. He must also get a common sense knowledge of the principles underlying the design, manufacture and selection of machinery.

This is a great deal to expect a student to efficiently absorb in four years, and it requires a most judicious selection in order that nothing unessential be allowed to enter, and that nothing essential be omitted.

Upon completing his technical college course at the University of Wisconsin of four years, an average student has spent at least 144 weeks of hard study, much of it of a practical workday nature. During this time he has been called upon to spend upward of five hours per day in class room and laboratories, and about as much more time in individual study. No one is likely to go satisfactorily through such a course unless he has a decided taste for engineering work; but many students find themselves capable of doing a considerable amount of extra work, and yet have sufficient time for recreation to keep their health and spirits. It is well for an engineering course to stand beyond the reach of students without a taste for the work, for a successful engineer must be pre-eminently an enthusiast, while he is at the same time a candid and careful thinker. Those who are not fitted by nature to become engineers are better placed in a general educational course at college, and they are then more likely to become useful to society and to themselves than if passed through the technical mill.

It may be here asked, Of what use is the severely specialized education to the successful student in the engineering courses? The graduate does not become an engineer merely because he has successfully met the college examination. College cannot make an engineer, however practical the course of study may be. Practice has made thousands of good ones without the aid of the college, but I venture to say that these would frequently have become more eminent if they had received a thorough technical college course. While theory alone, wherever learned, cannot make a practical man, it is the one who can follow the guide of theory along the paths of practical work and experience who makes the fully developed engineer. In order, however, that neither theory nor practice may lead him astray, he must have a well-educated common sense. The eminent and eloquent engineer, Alexander L. Holley, well illustrated this in one of his addresses, when he said:

"Mere familiarity with steam engines is not, indeed, a cause of improved steam engineering, but it is a condition. The mechanical laws of heat were not developed in an engine house, yet without the mechanism which the knowledge derived through this familiarity has created and adapted, the study of heat would have been an ornamental rather than a useful pursuit. So in other departments. . . . When one in any art can make a diagnosis by looking the patient in the face rather than by reading about similar cases in books, then only may he hope to practically apply such improvements as theory may suggest, or to lead in those original investigations upon which successful theories shall be founded."

Another illustration of the advantage of the technical college course lies with the designer. To design good machinery is a natural gift, and to become thoroughly successful requires long experience, in order that the widely varying requirements may each be given due weight. Proper instruction at the technical school may here do much toward stimulating an appreciation of the lessons of experience. The considerations of primary importance to be followed in designing machines are admirably divided by Prof. A. W. Smith into four: 1st, adaptability; 2d, strength and stiffness; 3d, economy; 4th, appearance. In developing the design of a machine, the practical, but highly sanguine inventor often forgets all the considerations except the firs[t].

* T. M. Drown.
† *Nebraska State Journal*, March 19, 1892.
‡ Abstract of a paper read before the American Institute of Electrical Engineers.

A theoretical draughtsman may figure the strength to great precision by formulas that may not fully cover the required conditions, and in the meantime forget the other considerations. When the design reaches the shopman, it must be altered to suit his views of economy, as the prime factor. A machine is thus produced that has lost part of its adaptability as designed, and has neither sufficient stiffness to properly do its work, nor a thoroughly substantial, workmanlike appearance. The economical shopman has been defeated in his object, for the machine is hard to sell or requires costly repairs at the expense of the maker. A proper college course should sufficiently broaden a man, so that he can quickly appreciate the demands of the prime considerations of practice, and will apply his formulas with common sense and moderation. If we replace our three men in the machine transaction by men of equal experience and a technical college education of the right sort, the work of each should supplement the work of the other, and the product can be predicted, with some confidence at least, to be a satisfactory commercial one. The fault of much of the college training for engineers has been the lack of this education of the common sense or judgment. The result has often been graduates with as great a contempt for the practical man as the latter could return. These graduates have, it is needless to say, been a failure in their calling, and it is such men that technical colleges should not turn out. The best engineering schools desire to, and do, turn out men who have a capacity for practical work and research, and who are in a fair way to make useful engineers.

We can now usefully inquire into the specialized work that should be prescribed for the average electrical engineering student during his last two years at college. Up to this point students in mechanical and electrical engineering courses have received virtually the same instruction. Here, we hold, with several others, their paths should diverge. The student of mechanical engineering goes into careful study of shop practice, designing and utilizing various types of machinery, and smaller subjects. The electrical engineering student must receive a good working knowledge of the problems of the mechanical engineer, but he must above all be trained in the practical problems of electrical engineering. He, therefore, goes into a study of that which will aid most in making him truly an electrical engineer. His knowledge must all be based on mechanical laws, but he must be much more than one-tenth electrical.

Before reaching his truly professional studies, the student should gain, during his course in physics, a common sense grasp of the elementary notions of electricity and magnetism, and of the "all-pervading law of Ohm." The latter can be properly enforced in the laboratory by placing in the student's hands ordinary electrical instruments, such as bridges, galvanometers, ampère meters, voltmeters, etc. Before beginning his specialized work, the student's knowledge of Ohm's law and its common results should have become almost instinctive.

With due regard for his preparation, it seems best to arrange the professional studies for the average electrical engineering student in four divisions, thus:

1. Electro-magnetism and its application to practical uses, with special reference to dynamos and motors.
2. Electro-chemistry (including primary and secondary batteries) and electro-metallurgy.
3. Alternating currents and alternating current machinery, including dynamos, converters, condensers, etc.
4. The special application of the preceding divisions in electric light, power, railway, mining and other types of plants.

The last division is allotted about twice the amount of time given to each of the others.

While higher mathematics is a useful aid in each of the divisions, its limitations as an agent must be carefully set forth in the class room and laboratory. For the purpose of educating the judgment and fully defining the limitations of theories and mathematical deductions, the laboratory is indispensable. As much as one-half of the total time spent by the student under the direct instruction of the professors of electrical engineering should be devoted to the laboratory. This work, moreover, should as far as possible deal with commercial improvements and machinery, and actually follow the methods of testing and research used in practice. Physics, chemistry, mechanics, steam engine, hydraulics, dynamos, electrolysis, alternating currents and other subjects, should all be properly represented by a commercial laboratory equipment, which is made useful in every day instruction under the direction of a man who has had experience in similar commercial work. The laboratory method of educating the student is unfortunately too little developed in many of our engineering schools, but a strong movement has begun in most schools to increase it in efficiency and amount. At the University of Wisconsin we carry the laboratory instruction as a part of the required work in every subject in which it is possible.

While the specialized course of the electrical engineering student during the last two years is largely devoted to strictly electrical engineering, he is also given proper class room and laboratory instruction in useful allied subjects, such as the steam engine, boilers, water wheels, laws of contracts, etc., as has been already explained.

Students who are mature and show that they can usefully specialize more severely than is done in the regular prescribed course are permitted, by election, to devote a greater proportion of their time to either of the first three divisions already enumerated. Thus a student may have reason to know that a thorough course in electro-metallurgy will be specially useful to him. In this case his work in the second division is increased beyond the course requirements, and his work in the first and third divisions is proportionately decreased. Other things being equal, a student who has thus arranged his course may graduate with his classmates who have followed the fixed course, as laid down. In the same way, a student of sufficient maturity, who feels assured of special advantages in the field of electric transmission of power or electric railways, may increase his work in the first or third divisions and proportionately decrease it in the second.

In order that the student may have a fair opportunity of growing "wiser and better" in the practice of his art he should be given reasonable encouragement. As Mr. Holley once said, an understanding should obtain "among the owners, directors and commercial managers of engineering enterprises that it is not a matter of favor, but a matter of as much interest to themselves as to any class, that young men of suitable ability, and of suitable preliminary culture, however acquired, should have an opportunity and encouragement to master the practical features of technical education in works, not as mere apprentices, but under reasonable facilities for economy of time and completeness of research."

Long Distance Transmission for Lighting and Power.*

BY CHARLES F. SCOTT.

The public interest in electrical subjects is continually sustained by the announcement of discoveries and projects which border upon the wonderful and extreme. In power transmission, one of the most inviting and promising fields, general expectation has been raised to commercial operation over great distances and at very high pressures. But many schemes which are readily planned with glowing outlines to accomplish wonderful results are defeated by difficulties encountered in details and unforeseen obstacles.

The test of practical operation has been applied in but few cases, and the severe test of continued operation over a considerable length of time is of rare occurrence. The latter test is one of great value and possesses a commercial significance which makes it of the highest importance. The continued and successful operation of one plant for a year, under extreme conditions of situation and service, is of higher value in testimony to the practical development and possibilities of electrical work than many elaborate projects, or the operation of novel apparatus for a short time.

It is with this idea in mind that a description is here to be given of two plants, one for lighting and the other for the transmission of power. The conditions which have been met include a very considerable distance, extreme difficulties of climate and roughness of country, exacting requirements in continuity of service, and a pressure above that ordinarily used in the class of machines employed. The plants to be described are the first of their type installed in this country, and the apparatus in the power plant is of a kind that has not been heretofore used. The type and construction of the machines and the arrangement of apparatus are new in many particulars, and as they have contributed largely to successful operation they will be described with some minuteness. Alternating current machinery is employed, constructed by the Westinghouse Electric and Manufacturing Company, the pioneer company in alternating work in this country.

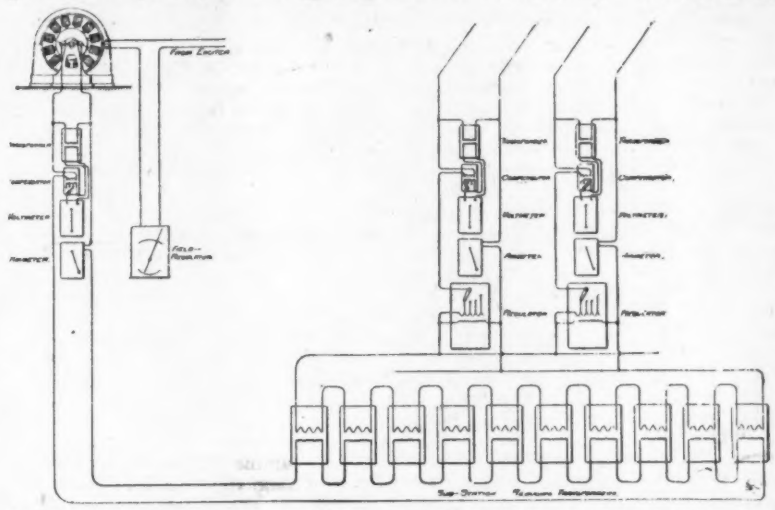


FIG. 1.—LIGHTING PLANT AT PORTLAND. DIAGRAM OF APPARATUS AND CONNECTIONS.

The lighting plant was first installed. It is operated by the Willamette Falls Electric Company, of Portland, Ore. The general requirements are those which electrical transmission is admirably adapted to meet. Portland, a city marked for its prosperity and rapid industrial growth, has not the great advantage of proximity to developed coal fields, so that power, the fundamental requirement for industrial activity, cannot be obtained cheaply from this source. Another supply of energy, however, is found in rich abundance. The falls of the Willamette River at Oregon City, in the combined points of size, accessibility and nearness to the seaport, are unequaled. These falls, estimated at from 200,000 to 250,000 h. p., are about 13 miles from Portland, and it requires but a moment's thought to appreciate the value of an agent which can make this power available in the city.

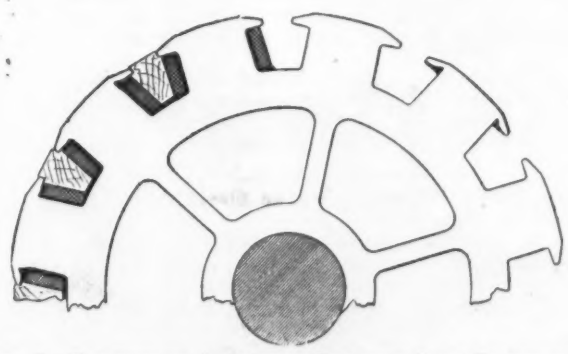


FIG. 2.—SECTION OF ARMATURE SHOWING IRON DISC WITH THREE COILS IN PLACE.

The Willamette River is about one-quarter of a mile wide, and the fall is about 40 feet. The present station is located on an island in the middle of the river. Victor wheels of 300 h. p. are geared to horizontal shafts, from which the dynamo belts pass to an upper floor at an angle of 45 degrees. Two alternating current dynamos for incandescent lighting are driven by each wheel. The current, at a pressure of 4,000 volts, passes directly to the line of No. 4 B. & S. wire, which is carried on ordinary double petticoat glass insulators across the level country to a sub-station in Portland. The current is received at 3,300 volts by transformers in the sub-station and is reduced to 1,100 volts, for distribution by various circuits through the city to ordinary transformers, by which it is reduced to 50 or 100 volts.

When the apparatus was designed, it was not considered practicable to generate 4,000 volts with the ordinary type of machine, in which the wire is wound upon the surface of the armature, on account of the difficulty of insulating for more than 1,000 or 2,000 volts. The work was undertaken with a new type of armature, which is specially noteworthy, as it has rendered high potentials practicable in a machine of simple construction.

The field of the dynamo is of the ordinary type of alternating current machine in use in this country. The casting is circular in form, with 12 inwardly projecting poles of laminated iron, on which the field coils are placed. This type of machine combines simplicity with rigidity and strength, as both bearings and the lower field are in one casting.

The armature is built up of laminated discs, which are punched with 12 T-shaped teeth. The armature coils are wound in a lathe, are carefully taped and insulated, and are then placed over the teeth and sprung in under the projections. The space between adjacent coils is filled by a block of wood which holds them in place securely. This form of construction gives all the advantages of machine winding over hand work, allows ample insulation between coils and core, protects the coils from mechanical injury, holds them in position without the use of band wires and makes the replacing of a damaged coil comparatively simple. The field current is supplied from a direct current machine and the main current is taken from two collecting rings on the armature shaft. The reducing transformers are placed in a vault in the substation at the city. They are arranged in banks or units of ten. Each bank is supplied by a separate dynamo and has a capacity of 1,250 16 c. p. lights. The coils of the transformers are separately wound and taped and are separated from one another and from the iron by strips of wood. The primaries are connected in series for receiving 3,300 volts and the secondaries are in series for delivering 1,100 volts, so that there are 330 volts in the primary and 110 volts in the secondary of each converter. This method of connection throws small differences of potential in any single coil and permits the use of conductors of good size. The necessity for special insulation is between the coils where there is ample room for placing it. A transformer may be readily cut out of circuit by short circuiting its terminals, and in case of an accident in which a coil becomes short-circuited the E. M. F. on that transformer disappears and the others are called upon to do a larger share of the total work without interfering with the service. The efficiency of the transformer at full load is 96 per cent.

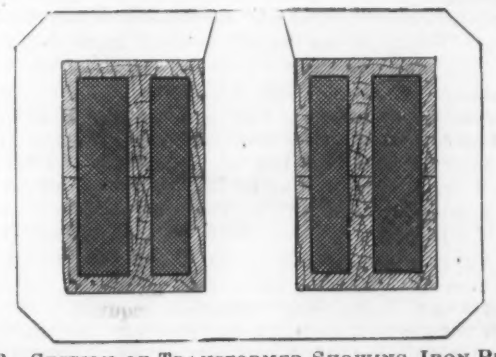


FIG. 3.—SECTION OF TRANSFORMER SHOWING IRON PLATE AND PRIMARY AND SECONDARY COILS SURROUNDED BY WOOD.

The operation of the system is simple. The voltmeter or potential indicator is supplied by the secondary of a converter reducing in the ratio of 30 to 1. In the voltmeter circuit there is placed a compensator, which is a small transformer with its primary in series with the main circuit, and its secondary in series with the voltmeter circuit, and connected in such a way that the compensator pressure which is proportional to the main current is opposed to that of the converter. The compensator is so adjusted as to introduce into the voltmeter circuit a counter E. M. F. proportional to the loss in the conductors, so that the voltmeter indicates the potential at the distant end of the line. The compensator effects the same result as pressure wires run from the point of supply back to the station. The E. M. F. at the dynamo is adjusted for each load by regulating the field current so that the voltmeter shows the proper indication, thus keeping the pressure at the sub-station constant at 3 300 volts. The pressure at the dynamo is slightly in excess of this at light loads, and is increased to 4,000 volts at full load, to cover the loss of transmission. The secondary current from the reducing transformers is treated as if it were received directly from a dynamo. On each supply circuit from the station there is a voltmeter with a compensator set for the loss in this circuit. The exact adjustment of E. M. F. on a circuit is made by a regulator, consisting of a transformer with its primary connected directly across the main terminals, and a secondary divided into small sections, each having an E. M. F. equal to one per cent. of the primary. Any number of these sections may be placed in series with the supply circuit, thus varying the E. M. F. at will. The form of regulator is of high efficiency, as it converts but a small percentage of the total energy, and the loss is a small fraction of this percentage.

The simplicity of the system, and the perfection of its operation, both from a theoretical and practical standpoint, are noteworthy. The electrical system receives mechanical energy, converts it into electrical energy, in a form suitable for transmission over a distance too great for other agents, and by the simplest form of conductor, and transforms it to a pressure suitable for commercial lighting. And yet in the whole system there is but one element in which there is mechanical motion, and that motion is simple revolution. The only wear and friction is in the dynamo, and its bearings are easily lubricated. The one point at which the high-tension conductors need be exposed is at the dynamo, where the

*A paper read before the American Institute of Electrical Engineers.

brushes and fittings are of the simplest sort. The line does not deteriorate by carrying current, and, as a piece of apparatus, the transformer, in simplicity of construction and operation, is unrivaled.

The plant was first installed with two incandescent machines and started nearly two years ago. Since that time five additional machines have been added, so that there are now seven, each with a capacity for supplying 1,250 16-c. p. lights, in Portland. The total capacity is 8,750 lights. The dynamos run admirably. There was one night when several armature coils were burned out, which was attributed to an iron wire falling across the main line and connecting several of the circuits, grounding them. Otherwise there have been no difficulties to speak of with regard to the operation of the machines. The superintendent of the plant states that the line has given very little trouble, much less than would ordinarily be expected from a city line. He also says that "the converters in the sub-station have not given one

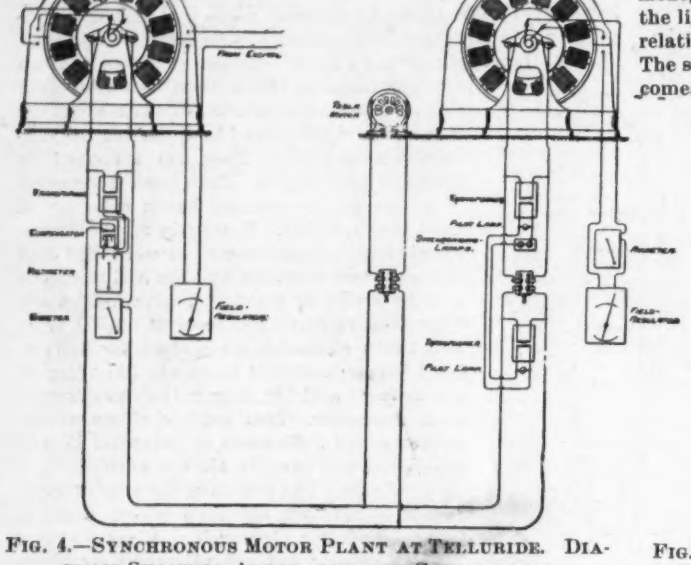


Fig. 4.—Synchronous Motor Plant at Telluride. Diagram Showing Apparatus and Connections.

minute of trouble, and have not cost one cent for repairs." One explanation of the success of the plant is the intelligent policy of the general manager, in harmony with his statement that, "It is not the first cost which counts, but the cost of throwing out and replacing apparatus."

The same policy has happily governed the installation of the second plant to be described—the power plant. This is located near Telluride, Colo., and is owned by Mr. L. L. Nunn. The Gold King mill requires power for operating its crushers and stamps, and fuel can come only from long distances at enormous cost. A few miles from the mill there is a water power, but the country between the two points is steep and rough, and for many months in the year is covered with snow. Electricity is the one means of getting the power from its source to the mill. The conditions are of the most favorable character for demonstrating the value and possibility of electrical transmission.

In this plant a Pelton wheel receiving water through a two-foot steel pipe, under a head of 320 feet, drives an alternating current generator. The current is carried over a line of bare wire to the mill, which is nearly three miles distant, and drives an alternating current synchronous motor of 100 h. p. The generator and motor are machines of the same size and form of construction as the dynamos at Portland, already described, and differ from these only in some minor modifications.

The generator is provided with a composite field winding. A part of the magnets are excited by direct current from a separate machine, and the rest are excited by a current from the generator armature, which is proportional to the main current and is commutated by the equivalent of a two-part commutator. The adjustment is such that the E. M. F. on the main terminals rises as the current delivered by the machine increases, compensating for line losses and keeping the pressure at the motor 3,000 volts. The speed is 833 revolutions, giving 10,000 alternations per minute. The switchboard and regulating appliances are similar to those in the station at Portland. Ordinarily no adjustment is required after the machine is started, and the attendant has little to do besides looking after the mechanical running of the apparatus.

The motor is similar to the generator except in the manner of exciting the fields. The field current is obtained, not from a separate machine, but from a second winding parallel with the main coils around the teeth of the armature. This current is commutated and passes through the field coils. The motor, as already stated, runs in synchronism with the generator, and although the general theory of the synchronous motor is well known, it may be briefly outlined. If the terminals of two alternating current machines giving the same number of alternations per minute be connected together, and one be driven by an engine or other source of power, the second will run as a motor and will do work. The impulses of E. M. F. which are generated in each machine occur simultaneously and are opposed in direction, so that only a small current flows through the circuit joining their armatures. As the motor is loaded, its armature is held back slightly and its impulses of E. M. F. do not exactly oppose those of the generator. This causes an increased current to flow which prevents further change in the position of the motor armature and holds its speed in synchronism with that of the generator.

A motor of the synchronous type requires an auxiliary device for starting, which, in the present plant, is a small motor—a special modification of the Tesla type. This has a laminated field with inwardly projecting poles on which coils are placed which receive current directly from the main circuit. The coils on the revolving armature are short circuited. There is, of course, no commutator or collector, nor is there any exposed contact or auxiliary apparatus except the switch. This motor comes quickly to its normal speed and then has ample capacity for bringing the armature of the large motor up to speed. Both of the machines are belted to a countershaft and the ratio of the pulleys is such that the speed of the large motor is a little greater than that of the generator. The large motor is then excited and runs as a self-acting alternating current dynamo at the nominal E. M. F. of the circuit. The small motor is then switched off and the speed of the large machine gradually falls until it is approximately equal to that of the generator. The relation between the speeds of the two machines is indicated by the fluctuation in the intensity of lamps, which are connected in series with the secondaries of two converters, whose primaries are connected with the generator and motor respectively. When the E. M. Fs. of the two machines are in the same direction current will pass through the lamps, and when they are opposed there will be no current.

If the motor is running a little faster than the generator its E. M. F. will be in the same direction as that of the generator at one moment, and will be opposed at the next moment, causing a corresponding variation in the intensity of the lights. At the time of slow variation and proper phase relation the machines are connected by closing the switch. The small motor is disconnected by its friction clutch and comes to rest, and the load is then thrown upon the large

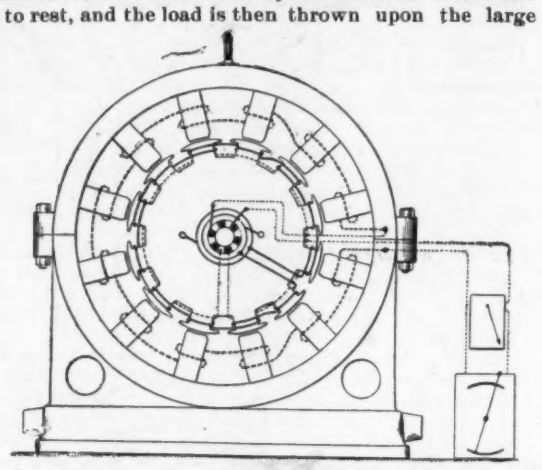


Fig. 5.—Synchronous Motor. Diagram Showing Windings.

motor by a second clutch. The operation of starting require but one man, and is accomplished in about two minutes. The rheostat in the field circuit is adjusted to give the proper field current as indicated by the ammeter. This is done when the motor is started and it may then run indefinitely with varying loads without requiring any adjustment whatever.

When the motor is running, the only things to be cared for are the brushes and the bearings. The high tension brushes —the only point besides the switches where the high tension is exposed—will run for a week without adjustment, the exciter brushes run without sparking and the lubrication of the bearings is well provided for. The construction and operation of the motor is strikingly simple in comparison with the steam engine, which it replaces, with its many moving parts and intricate motions.

A few points illustrating the characteristics of the synchronous motor may be mentioned, as they are of both theoretical and practical interest. The connection of the motor to the generator is not a delicate operation. If the motor is running above synchronous speed at the time of connection with the generator it instantly adapts itself to the proper speed. If the motor speed is slightly lower that than of the generator it may fall into step when the switch is closed, but if it be running considerably slower it will not come into synchronism, but will further decrease in speed. When this occurs, the switch of the large motor is opened and that of the starting motor is closed, bringing the machine up to full speed again without any injury to the apparatus. If

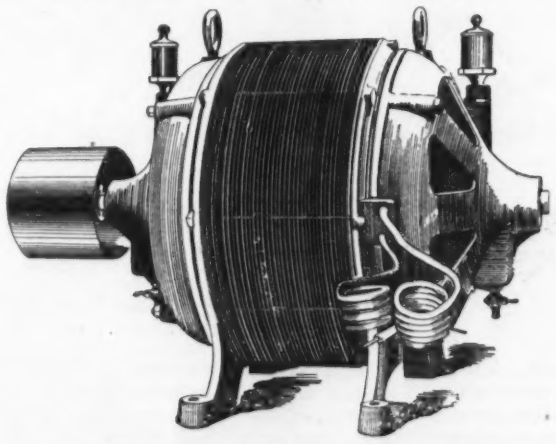


Fig. 6.—Tesla Starting Motor.

the E. M. F. upon each of the machines before connecting them be 3,000 volts it will remain unchanged when they are connected. If the field current of either machine be increased the E. M. F. will be raised, but the field current of the other machine may be lowered and the resulting E. M. F. made equal to 3,000 volts. The current flowing between the machines depends upon the relative field charges, and is least, whatever the load may be, when the two machines are equally, or very near equally excited. The field current of either machine may be made zero, and the motor will still run, but with greatly reduced capacity. In a test with machines of a smaller size the E. M. F. was 2,000 volts when the two field charges were equal. When the field charge of either machine was cut out it fell to 1,200 volts, and the current increased very considerably.

The explanation of the fact that the two machines may run together with widely differing field charges is easily understood when the extra flow of current at that time is taken into account. If the field charges are different the E. M. F. tends to be different also, and a current flows between the generator and motor, which is of such phase that it tends to strengthen the weaker field and to weaken the stronger one. Thus, when the tooth of the motor is in front of a field pole, the current flowing at that time is in such direction as to weaken or strengthen the field as may be required to make the E. M. F. equal to that of the generator. Difference of phase between E. M. F. and current has an effect upon the regulation of a dynamo which is easily shown by changing the character of the load. If a dynamo, with a constant field charge, is used for carrying an ordinary load of incandescent lamps, a certain drop in E. M. F. will result. But if the same current be delivered to an inductive resistance, such as a coil of wire, the starting motor, or a synchronous motor, when its armature is at rest or its field is not charged, the drop in E. M. F. will be considerably greater than with lamps. On the other hand, when the generator is supplying a synchronous motor running under normal conditions, the drop in one test was about half that which resulted from the same current to incandescent lamps. The current to the motor when running without load is quite small and increases in proportion as the load is added. With any definite load the current between the machines, as already pointed out, depends upon the relative field charges of the machines as well as upon the E. M. F.; but there is, however, a considerable range through which the field charges may be varied without materially affecting the current. If the load on the motor be increased to about twice its rated capacity it will fall out of synchronism and come to rest. The current, however, is held back by the self-induction of the motor armature and is not sufficient to cause immediate injury.

An efficiency test of the motor was made before shipment by driving a dynamo which was loaded. The current and E. M. F. received by the motor and delivered by the dynamo were measured and an allowance made for the loss in the dynamo. The full load efficiency in this way was found to be 93 per cent. In a test upon smaller machines of similar type the efficiency of the motor at full load was found to be 91.5 per cent. The efficiency of the synchronous motor system, leaving out loss in conductors, but including losses in generator and motor, in the plant for the delivery of 50 h. p., was found to be 83½ per cent. at full load, and 74 per cent. at half load.

Full load may be thrown on the motor suddenly. In the Gold King mill the stamps, which are operated by the motor, are usually left raised when the plant is stopped, in order to avoid the extra strain of lifting them when the plant is started. It sometimes happens that the stamps are left down and the motor is required to raise them all at once. When the clutch is thrown in, the current indicates that the load is considerably above the normal capacity of the motor, and yet it is started without difficulty or apparent strain.

The excellent current regulation with different loads, the tendency of the machines to normal adjustment when there is ordinary variation in the field currents, the small liability to injury when the motor is greatly overloaded, the high efficiency and ease of attendance, are points of great value in the practical operation of the system.

The pole line runs from the power station up the mountain to a height of 2,500 feet, and then crosses a rough but comparatively level country to the mill. The line at some places is at an angle of 45 degrees, and many of the poles had to be set in solid rock. The surface of the snow in winter is occasionally at the level with the tops of the poles, and parts of the pole line are practically inaccessible during some months of the year. This region is peculiarly subjected to lightning discharges, and special precautions are necessary to protect the apparatus. In one instance there were 42 discharges of the lightning arresters in as many minutes.

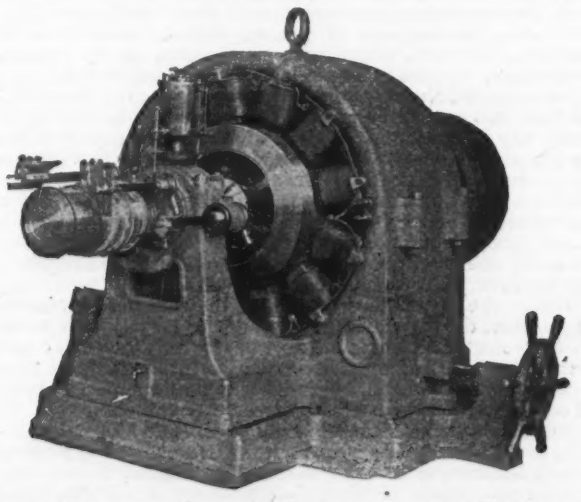


Fig. 7.—Machine Used as Generator and Motor at Telluride.

The plant was started for regular work in June of last year. An accurate record was kept from the middle of July to the first of May, showing the actual number and the length of the delays caused by electrical machinery. During these nine and a half months the system was in regular continuous operation six and a half days each week, with but few intermissions. The difficulties which were encountered were insignificant in amount and have resulted, not from any fundamental difficulty in the system, but have been caused by incidental defects or accidents which usually indicated their own remedy. The stops due to the electrical machinery resulted from a variety of causes and comprised the replacing of an armature coil damaged by lightning, renewing of fuses, fixing loose contacts, the examination of the line after a storm, and sundry other slight mishaps. The aggregate time lost on account of the electrical apparatus was, by actual count, less than 48 hours during three-fourths of a year. A recent report from the superintendent of the plant covering the time from Dec. 13 to May 1, shows that the plant was running 127 days with a loss of 19¾ hours, or,

as he puts it, an average of about nine minutes in a day of 24 hours. Although the plant was generally shut down each week for 12 hours on Sunday this was not practicable during a part of the winter, and the motor on one occasion was run continuously for 27 days without any stop whatever.

Such a record as this, with a new type of machinery, in a country where line construction and maintenance are peculiarly difficult, with practically continuous service, with attendants who were not electricians, with a high voltage, a considerable distance and large power, places transmission by the alternating current synchronous system beyond the stage of experimental trial and gives it the stamp of commercial success.

This success is confirmed in a substantial way by the immediate extension of the plant. A 50-h. p. motor is now being installed at a mill a few miles from the Gold King. An order has been entered for a 750-h. p. generator to be located in the power station, and a 250-h. p. motor for operating a mill about 10 miles distant. Lighting at Telluride, eight miles from the station, which has been heretofore done on a small scale on a circuit from the power generator, is being extended.

The large generator is a new design, and is notable as it has more than three times the capacity of any alternating current dynamo previously made in this country. Two machines of this size have been running for some months for incandescent lighting in St. Louis.

This dynamo is of a type similar to the machines at Portland and Telluride. The field has 28 poles, requiring a speed of 570 revolutions for 16,000 alternations, the conditions of running at St. Louis, and 357 revolutions for 10,000, as it will be operated at Telluride. The armature has T shaped teeth, as in smaller machines. The diameter of the armature is slightly over four feet and its length is about two feet. There is a third bearing at the end of the shaft outside of the pulley to relieve the other bearings from the severe strains resulting from belt tension. The total height of the machine is eight feet and its weight is 40,000 pounds. The electric efficiency at full load is over 95 per cent.

The extension of alternating current working, both for lighting and power, by the use of larger machines, is therefore already provided for.

The extension to greater distances is largely a question of E. M. F. Nearly every one is familiar with the rapidity with which the cost of copper diminishes as the voltage is increased.

If the cost be $100 with 500 volts it will be $25 at 1,000 volts, and $1 at 5,000 volts. The higher the tension, however, the greater the difficulty and cost of construction and the greater the liability to accident with apparatus and line.

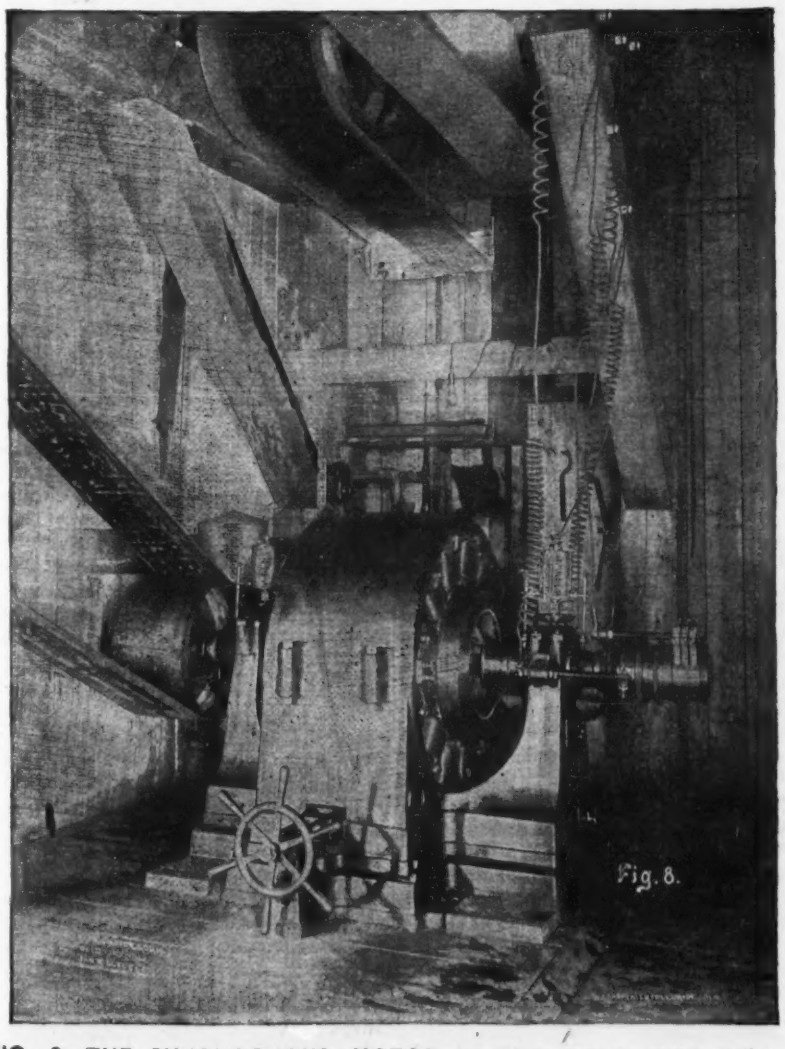


FIG. 8.—THE SYNCHRONOUS MOTOR IN THE GOLD KING MILL.

There are a few points in connection with this subject which may be noted without entering into a general consideration of it.

The smallest size of wire that can well be used for line work on account of its mechanical strength is about No. 6 B. & S. This wire will transmit with 20 per cent. loss 100 h. p. 10 miles at 4,000 volts, or twice the power half the distance. Unless these distances or powers are to be exceeded an increase in pressure would result in no saving in copper, but simply in a less line loss, which is already not excessive.

The use of 4,000 volts at the motor and a line loss of 20 per cent. requires an outlay for copper of only about 10 per cent. to 15 per cent. of the total cost of the plant when the distance is 10 miles. Unless, therefore, the cost of copper is to bear an insignificant proportion of the total cost it is unnecessary to exceed this pressure unless the distance be greater than about 10 miles.

These simple considerations show that pressures practically the same as those employed in the plants which have been described are ample for considerable distances. The same type of apparatus which has been successful in them is available for larger capacities. The fundamental elements required for electrical transmission in a very wide range of cases have therefore been tried and their success demonstrated.

For considerably longer distance, where pressures higher than about 5,000 volts are required, good practice indicates the use of transformers for raising the pressure at the generator and reducing it at the motor, similar in general to those employed at Portland. The increased pressure thus available greatly reduces the cost of copper required, and this reduction must, of course, be more than sufficient to cover the cost of the transformers. The prime requisite in a system for power transmission or distribution is simplicity.

FIG. 9.—VIEW OF GOLD KING MILL, ILLUSTRATING CHARACTER OF COUNTRY ACROSS WHICH POLE LINE IS RUN.

In this point electrical apparatus is scarcely to be compared with any other class of machinery. There is a marked difference, however, between the classes of electrical apparatus. In direct current machines the commutator is the characteristic feature. It is expensive to make, to maintain, and to renew. The insulation of the armature is much more difficult, because it is necessary to connect a hundred points in the winding to exposed pieces. The commutator is the part requiring the most careful adjustment and attention, both in construction and operation, and yet it is ordinarily the source of more difficulty than all other causes combined. It is, moreover, the principal element which limits the E. M. F. at which this class of apparatus may be operated, and, in order to secure the advantage of a high E. M. F., systems are planned in which the generator and motor is each composed of three or four distinct machines to be run in series, thus avoiding an excessive E. M. F. on any single commutator at the expense of many machines and multiplied parts. The alternating current machine substitutes for the commutator the simplest kind of contact—brushes sliding on plain rings.

The alternating current is anomalous. For years it had little place in literature and less in practice. Theoretically, it is intricate and complicated; and the earlier difficulties in its application caused it to give way to direct current. But the direct current is reaching its limitations in conditions which alternating current apparatus readily meets. The alternating current motor has been one of the most complicated and difficult electrical problems, and yet the first large alternating current motor installed in this country excels direct current apparatus in simplicity of construction and operation, in perfection of regulation, and handles with simple sliding contacts, running for a week without adjustment, a pressure which with commutators is impracticable.

There is another class of alternating current apparatus to which no reference has been made. The multiphase, or Tesla system, which has attracted much attention of late, possesses the characteristics of this type of apparatus, which readily adapt it for combining simple construction with the use of high pressures. There are also marked advantages in the characteristics of the motor which are of especial value where distribution of power is to be combined with transmission. Motors of this class are self-starting with load, and may be run either as synchronous motors or with one winding short circuited and no commutator or brushes. The latter is the ideal motor in point of mechanical construction. The simplicity and flexibility and range of the alternating current system make its possibilities the sole dependence of the largest enterprises, toward which the public and engineers are looking. The records of the plants at both Portland and Telluride demonstrate that these possibilities are being realized, and that work in this field is fast passing from experimental investigation into practical electrical engineering.

Series Electric Traction.*

BY NELSON W. PERRY, E. M.

[The first part of the paper was devoted to a summary of the acknowledged advantages of series systems in general over multiple arc systems for long distances, concluding as follows:]

In the one case the copper must vary as the demands and distances, the pressure remaining the same, and in the other the pressure varies, the copper and current remaining the same. In an arc light (series) circuit the wire will be of the same size whether it be erected to supply one lamp or sixty; whether the distance be one mile or five, and if, at any future time it be desirable to extend the line to double or treble the distance the wire already erected is amply sufficient for the part of the line it covers and merely requires extension to the desired point to meet all the demands.

With the arc lamp or other stationary translating device, arrangements were readily devised for automatically shunting the current around in case of disability of the translating device, or the desire to throw it out of service. Not so with a moving object, such as a street car. No means had been found to shunt the current around the latter, or in case it got out of circuit by means of the trolley getting off the wire, of automatically closing up the gap thus made, and the disability of one car became the disability of the whole line and of every car on the line.

Could this and some other difficulties be surmounted, the constant current possesses many advantages over the constant potential that seem to me would bring it into almost universal use for traction purposes, especially on interurban lines and in other cases where long distances are concerned,

It is my purpose to show how all this has been accomplished, and how the constant current system may be made as elastic in every way, at least on paper, as the constant potential, without sacrificing in any way any of the advantages peculiar to the system, and how it is possible to make each unit in such a system nearly if not quite as independent of every other unit as is the case in the system now in vogue.

[After describing at some length the series systems as installed by Prof. Short at Cleveland, O., and Huntington, Va., he states:]

I speak more freely of the defects of the Short series system from the fact that it has been abandoned by the Short company; and because its failure has been officially announced by its projectors, my object in dwelling upon it at such length being to point out more clearly some of the defects that must be remedied before the series can become a practical working system.

The system which I am about to explain may properly be described as consisting of a circuit interrupted by a series of breaks in multiples of two, or one consisting of a circuit interrupted by breaks in multiple series with each other—the breaks being in multiples of two. The conception then would be like Fig. 1.

But in order that a current shall pass around this circuit, it is necessary that one of the breaks in each multiple shall be normally closed. It matters not which one is closed, so our plan would now look like Fig. 2.

If a translating device should successively occupy each of these breaks, it would receive current during the time that its terminals connected the ends of the two broken wires, in proportion to the relative conductivity of the two paths open to the current. But we are not satisfied to have a portion only of the current pass through our motor—it is necessary that all the current must so pass. We must, therefore, make the resistance of the other branch infinite during the time in which

*Abstract of a paper read before the American Institute of Electrical Engineers.

the motor is bridging, through its terminals, the break, or, in other words, the normally closed branch must be broken.

If, therefore, we place an electromagnet in series with the normally broken branch, so that when vitalized it will open the switch in the normally closed branch, and allow it to close again by gravity or otherwise, when the magnet is devitalized, we have provided in a crude way for operating traveling translating devices in series. Our conception now would be represented somewhat by Fig. 3.

By this arrangement the moving device only receives a momentary impulse as its terminals touch the ends of the break, and would have to rely upon its acquired momentum to carry it to the ends of the next break. It will be apparent, however, that it is immaterial whether the device receives its next impulse by closing the next break in the circuit or whether it skips that one and gets it from any other break, either on that circuit or from one connected with an entirely different dynamo. It is this feature that permits the use in my system of sidings on single track roads and of forks (the skipping of one or more breaks), and the intercommunication between separate circuits (the jumping from a break on one circuit to a break on another).

It is desirable, however, that the moving device be impelled by as nearly a continuous force as possible, instead of by a succession of momentary impulses. Instead, therefore, of having the ends of the normally open break face each other as represented heretofore, we may extend these wires for some distance parallel with each other, and our plan assumes the form shown in Fig. 4.

And it is desirable that the interval of time during which the device is without current, viz., that occupied in passing from one break to the next, shall be as small as possible. This naturally suggests having the normally open breaks all

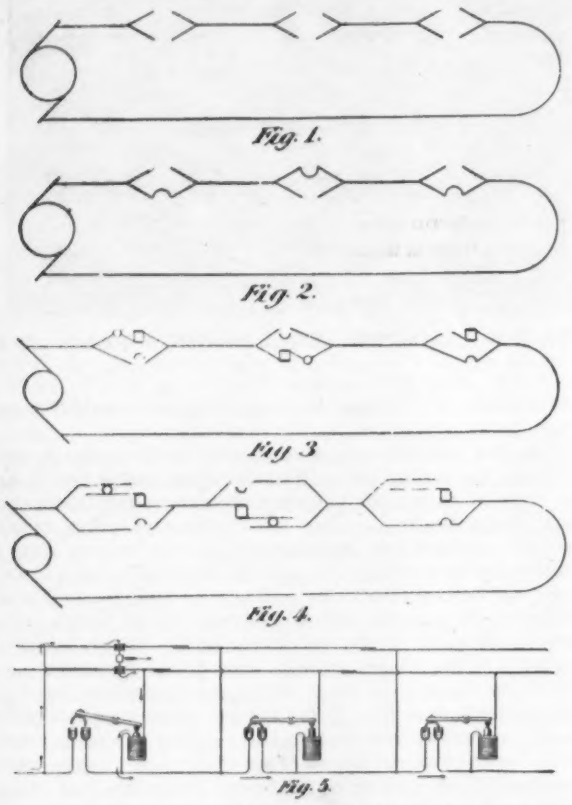


Fig. 1.

Fig. 2.

Fig. 3

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig 10.

DIAGRAMS ILLUSTRATING THE DETAILS OF ELECTRIC TRACTION BY SERIES METHODS.

on the same side of the normally closed breaks, and if these parallel wires be continued so as to overlap those constituting preceding and succeeding breaks, a car or other moving translating device may pass from one break to another without even momentary interruption of current. In Fig. 5 the lower line, which I call the "feeder," contains all of the normally closed breaks, represented by mercury cups normally connected electrically by a fork dipping into them, which constitutes a double pole switch actuated by an electromagnet in the manner to be described.

The upper pairs of wires, which it will be seen are merely the parallel extensions of the other possible path for the current, are in multiple with the path through the mercury cups. One of each of these pairs of wires, which will hereafter be denominated sections, is connected to the feeder wire on one side of the mercury cups, and the other has a similar connection on the other side. The two wires of each section, normally without electrical connection with each other, constitute what has been termed the "series of breaks normally open." If, however, these two wires be connected electrically through the terminals of a motor, the latter will be in multiple with the mercury cups and momentarily receive only the current due to the relative conductivity of the path thus offered. By the arrangement shown in Fig. 5 the electromagnet which opens the mercury cup switch is in series with the motor circuit, and the latter no sooner receives current than the former is actuated, the switch is opened, and the whole of the current which was momentarily divided between the two branches is diverted to the motor.

If the corresponding wires of the succeeding sections be caused to overlap without making electrical connection with each other, and these laps be staggered as shown, a means is provided whereby the motor prepares the succeeding section for occupancy before wholly passing out of the one it is about to leave, and accomplishes this without interruption to the current. Figs. 6 and 7 show how this is done, and the arrows show the paths taken by the current as the transition takes place. When the motor is in the position represented in Fig. 5 there is but one path for the current—viz., around the open switch in the feeder and through the electromagnet by which it is kept open, back again to the feeder.

As the motor proceeds to the right, one of the terminals first embraces the lower lap, thus offering two paths for the current—one passing through the switching arrangement that controls the section the car is about to leave, and the other through that controlling the section it is about to enter (see Fig. 6). As it progresses still further this terminal passes beyond this lap at about the same time that the other terminal embraces the other lap. This leaves the first switch without current and the succeeding switch is automatically opened. There is no break in the circuit, however, even during the short interval occupied by the two switches in acting, for while the further terminal embraces the further lap, both of the switches concerned are short circuited as shown in Fig. 7. Before the further terminal has passed beyond the lapping portion of the two succeeding wires, the first switch will have closed and the succeeding switch will have been opened, thus diverting all of the current to the section upon which the motor has now entered.

Fig. 8 shows another arrangement by which a motor is enabled to pass from one section to another without interrupting the circuit. In this arrangement the ends of the sections while mechanically continuous are electrically disconnected but do not lap as before. The break in the wires connected with the switch actuating device is longer than that between the other two wires. The larger gap, however, is lapped by a subsidiary conductor, which short-circuits the switch actuating the section the motor is about to enter, as shown. As the car proceeds from left to right, before both its trolleys have passed off the section, one of its trolleys has embraced the subsidiary conductor and the electromagnet controlling that section is cut out of circuit and the switch drops. While the switch is dropping, however, the current continues to flow through the companion wire, through the motor to the subsidiary wire and around the switch actuating the section it is entering.

Fig. 8 represents a branched or forked road operated by a single dynamo. In the arrangement shown in Fig. 8, where the branch road is operated by the return circuit, a car turning to the left would really skip from the first section of the road to the very last, if we count them in the order in which they receive current, whereas in going straight ahead it would pass from section 1 to section 2, etc., counting them in the same order. In Fig. 9, however, which represents a similar road operated by the loop system, a car taking the left hand branch would pass from section 1 to sections 2 and 3, whereas if it went straight ahead it would pass from section 1 to sections 4 and 5. It will be apparent from what has preceded that in neither of these cases does the skipping of one or many sections involve an opening of the circuit.

But, returning to Fig. 8, and following the car still further in its progress from left to right. We left it standing with one trolley on the further wire and the other on the subsidiary or short-circuiting conductor. In this position the current will continue to pass through the motor only so long as the switch actuating that section requires to fall into the mercury cups. Immediately that has occurred, which will be accomplished before the further trolley has passed from its wire, the motor will have been short-circuited and the car will, by its acquired momentum, pass from the system without sparking or other disturbance of the circuit. If the acquired momentum should carry the car to another section of the same system, or to a section connected with an entirely separate system, all that is necessary to enable it to proceed would be some arrangement by which the switch controlling the section upon which it was entering could be opened by the entrance of the car itself. It will be evident from Fig. 10, which represents two connecting roads operated by separate dynamos, that it matters not as far as the integrity of either circuit is concerned, whether the car goes to the left or to the right; in either case the circuit is closed before it leaves a section, and as it enters the succeeding section it does so before opening the switch which actuates that section, and it is entirely immaterial whether that section belongs to the same system as the one just left, or to one entirely foreign to it. If only the proper switch can be opened the car may proceed on its way on either system of roads. In order to accomplish this automatically, each car may be provided with some such an arrangement as is shown in Figs. 11 and 12. M is a solenoid magnet in series with the motor D; L is a lever pivoted at P and playing between the two stops, but when not actuated by the plungers of M kept in contact with the lower stop by the springs; B is the local battery; W, W^1 are the trolley wires, and C is the mercury switch connecting adjacent sections of the feeder wire. As long as the motor is receiving current from the feeder, as is the case in Fig. 11, the current must pass through M, which, by its pull on the plungers, maintains the lever L against the upper contact. As the trolleys pass off from a given section and the motor loses its current as before described, the spring S causes the lever to make the lower contact (Fig. 12), thus throwing the battery B into the circuit, W, F, C, F^1, W^1. The moment the trolleys enter upon a new section this circuit is closed, the local current passes through the feeder switch magnet and opens the switch C, and diverts the current from the feeder to the section just entered. This stronger current actuates the lever L, again bringing it against the upper contact and cutting the battery B again out of circuit. Since the battery B is only momentarily in circuit, the cost of maintenance will be insignificant.

On single track roads, where turnouts are required, the turnout constitutes merely an additional section to one side of the main line, which is skipped by the car keeping the main track, and taken by the other car in passing. It, like every other section, has its own individual controlling switch, and when both the main track and siding are occupied by cars, their motors are arranged in series with each other, as represented in Fig. 13. By following the arrows the course of the current can readily be understood.

But both of the plans thus far discussed possess serious faults. In both we have provided a means by which a car may leave one section on a given road and enter another one on the same or another road without breaking the main circuit, provided the car is always going in the same direction. In all of the cuts thus far, the car is supposed to be going from left to right, and the switches are arranged accordingly; but, if we examine the drawings again, it will be found that in the plan suggested in Figs. 5, 6 and 7 if the car were going in the opposite direction, the circuit would be momentarily broken as it left one section and would fail to divert the current to the section it was entering. In the second plan, outlined in Figs. 8, 9, 10 and 13, the car is momentarily without current whenever it passes from one section to another.

By combining the two plans, however, all of the difficulties seem to be removed. Figs. 14 and 15 show how this combination is effected, and the courses of the current when the motor terminals are in different positions on the wire. It will be noticed that, as in the first plan described, the trolley wires of adjacent sections are lapped, and that these laps are staggered; that parallel to, but insulated from, the nearer laps, is placed the subsidiary wire which short-circuits the switch to the right. The switch-controlling magnet, as is shown, has two coils wound cumulatively, and may be operated either by the current passing through the subsidiary wire, by that passing through the nearer trolley wire, or by both when it takes both paths.

The supplemental conductors and the laps in the trolley wires are so arranged relatively to each other that when a car is traveling in the direction of the main current, as the trolleys approach a lap, the trolley traveling upon the wire connected with the switch will contact with the supplemental conductor before reaching the lapping portion of the trolley wires, and the companion trolley will reach its lap after the first trolley has reached its lap and before it has passed beyond the supplemental conductor, while, with a car traveling in the opposite direction, the order will be reversed, the trolley upon the wire not connected with the switch first reaching its lap, after which its companion trolley reaches first its lap and afterward the supplemental conductor. By this arrangement, in whichever direction the car may be going, in passing from one section to another,

it first short-circuits the switch controlling the section it is about to enter, next diverts a portion of that current to that switch, and finally all of it, cutting the switch controlling the section it has just left entirely out of circuit. In this manner the transition is accomplished in either direction from one section to another, either of the same or another connecting road, without spark or interruption of circuit.

Should either one or both trolleys leave the wires or the circuit through the motor in any other way become broken, the magnet controlling the switch to that section would be left without current and the forks would immediately drop into the mercury cups renewing the circuit through the feeder wire almost instantaneously. There would, however, be an interruption of the current while the fork was dropping. Even this slight interruption may readily be avoided by connecting with the switch any of the devices so successfully employed to obviate the same difficulty in arc light circuits.

Should a second car run upon a section already occupied, the two would be thrown in parallel and both would stop. This arrangement therefore constitutes a most perfect automatic block system, not dependent upon frail human nature, but sure and positive in its action. On interurban electric roads, where it is even now proposed to reach greater speeds than are customary or attainable with steam locomotives, the importance of this feature cannot be overestimated. Not only will collisions be rendered practically impossible, but by putting semaphores or other signaling devices in the wires, connecting the main feeder with the two trolley wires, each car as it enters a section will automatically set a signal at each end of that section showing that the section is occupied, and when it has left the section, set another, indicating that the way is clear. These signals cannot fail to act, for being in series with the motor, they must receive current when the motor does, and lose it when the latter has passed out of the block. This seems to be the solution of the block system, as it eliminates all the uncertainties inseparable from a dependence upon human intelligence and watchfulness.

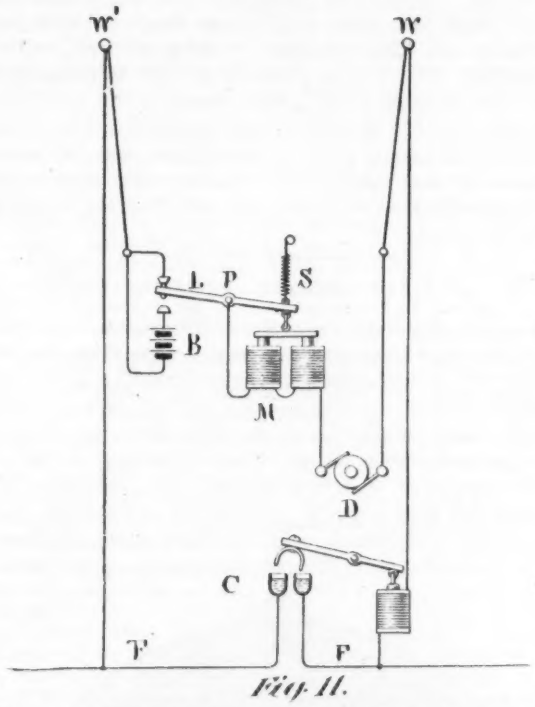


Fig. 11.

DIAGRAMS ILLUSTRATING THE DETAILS OF ELECTRIC TRACTION BY SERIES METHODS.

This system will no doubt be criticised, first, on the score that it is a double trolley system, which many are opposed to on general principles, and, second, on the score of high potentials necessarily involved in series distribution to long distances. Anticipating these, I will say in regard to the first, that however valid the objections may be to the double trolley on multiple arc roads, they have but little force as applied to series circuits. In the latter, since both the wires on all sections not occupied by cars are of the same potential, the difficulties of insulation of the one from the other disappear entirely. Then again, I am satisfied, with an intimate knowledge of the electric roads in Cincinnati, where with one exception they are double trolley multiple arc roads, that most of the objections raised against them are greatly magnified. They certainly have the decided advantage over the single trolley of being independent in their operation of the condition of the track, their chief objection being the difficulty of insulating the positive and negative wires from each other (which we have seen does not hold in series roads) and the multiplication of wires, crossings and switches where many lines converge and cross. In suburban districts where these complications do not occur (and this system is particularly adapted to such) the double trolley multiple arc system is in many respects superior to the single trolley. Mr. John Kilgour, president of the Cincinnati Street Railway Company, is justly proud of the Avondale double trolley road (a suburban line), and I doubt if there is a more successful road in the country than this.

In regard to the other objection to the series method, viz., the high potentials, the method outlined in this paper permits the use of any number of feeders, each of which may be used to supply a different portion of the road, thus reducing the potential, which in series distribution is the variable quantity, in the same manner exactly that the "drop" is obviated in parallel systems.

Not long since there was a very animated discussion at a meeting of the Institute as to which was the better method of electric street car control—that of commutating the field, or the other one, of employing a rheostat. The constant current system simplifies matters, at least in this respect, in that neither commutated fields nor external resistances are required in regulation.

As to the cost of installation, the comparison is much in favor of the constant current method on account of the extreme simplicity of the plant required and the smaller size of both motors and dynamos for the same output. But the economy in plant becomes most obvious where high potentials are used, and these are always necessary where long distances are concerned.

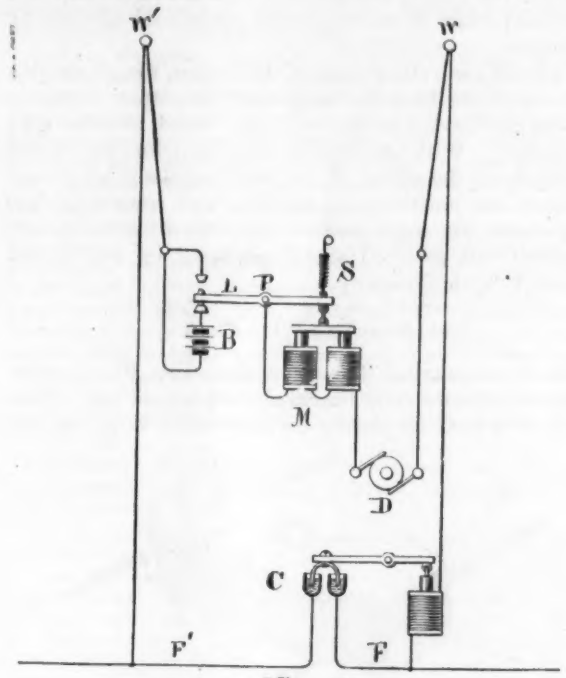


Fig. 12.

DIAGRAMS ILLUSTRATING THE DETAILS OF ELECTRIC TRACTION BY SERIES METHODS.

But important as are the economies in installation and in transmission of large energies to long distances, there is another that greatly outweighs them, viz., the economy in operating expenses. In this respect the series method is almost an ideal one. In the parallel or multiple arc method, when a car is going downhill or is being checked, the whole of its $\frac{mv}{2}$ is absolutely thrown away in the application of the mechanical brake. Not so with the series system. The mechanical brake need never be used except in the case of an emergency. By merely reversing the position of the brushes, the motor becomes, for the time being, a dynamo in series with the one at the power station, driven by gravity or the acquired momentum of the car, and the energy thus absorbed, while checking the car or bringing it to a standstill, is thrown onto the line for use elsewhere. One of the arguments used in favor of the cable road is that a car descending a grade assists another one which is ascending. If this be an argument where at least 75 per cent. of the engine power is consumed in dragging the cable alone, how much more valid should it be if the same thing could be accomplished where there was no cable to drag. Such, in fact, is the case with the series method. A descending car or one being checked assists another car that is ascending a grade or being started from rest, just as truly as it would if the two were connected by cable, and the energy thus thrown onto the line continues to contribute to the economy of the system to the last turn of the wheels. This is not mere theory. Professor Short demonstrated its actuality on the South Broadway line in St. Louis by disconnecting the circuit entirely from the dynamo, and causing one car to partly ascend a grade on one part of the line by electrically braking a descending car on another part of the line.

The importance of utilizing electrical brake power, which is impracticable in the parallel system, is emphasized by some experiments on the Third Avenue Elevated R. R., New York, instituted by Mr. Frank J. Sprague, to determine in

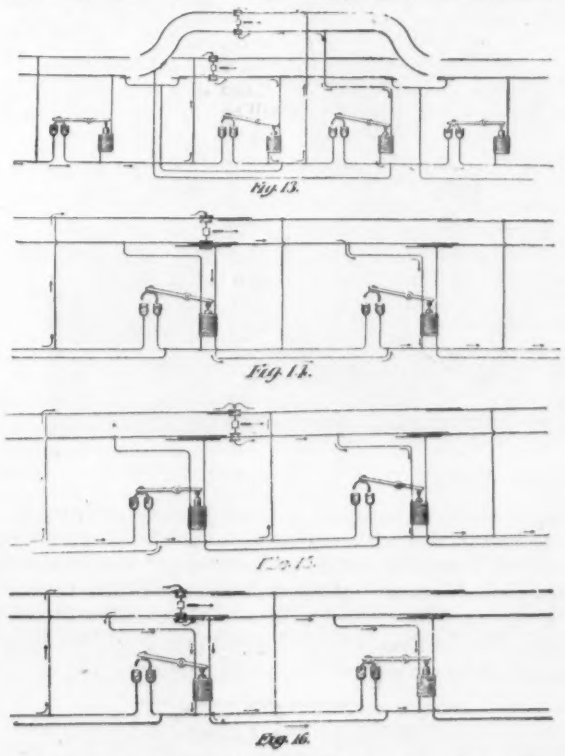


Fig. 13.

Fig. 14.

Fig. 15.

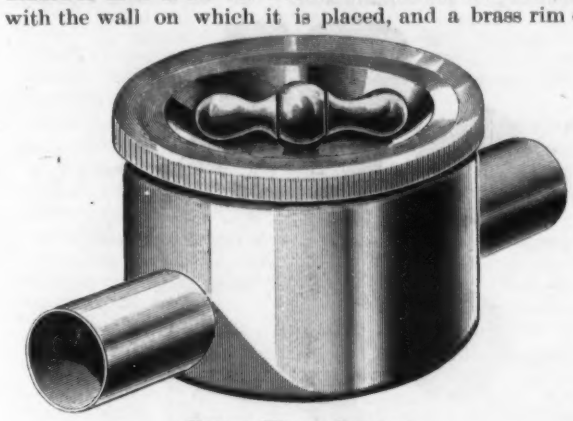
Fig. 16.

DIAGRAMS ILLUSTRATING THE DETAILS OF ELECTRIC TRACTION BY SERIES METHODS.

what manner the power generated was utilized. The result of these was that 83 per cent. of all the power utilized was consumed in overcoming gravity and the inertia of trains, and only 17 per cent. was actually consumed in traction.

A New Flush Switch.

The new 10-ampère flush switch, illustrated herewith, is manufactured by the Interior Conduit and Insulation Company of New York, at the suggestion of a prominent architect, and is said to have received high indorsement from the electrical trade. The accompanying illustration shows the features of the switch. A notched cover is indented so as to allow the handle of the switch to be flush with the wall on which it is placed, and a brass rim ex-



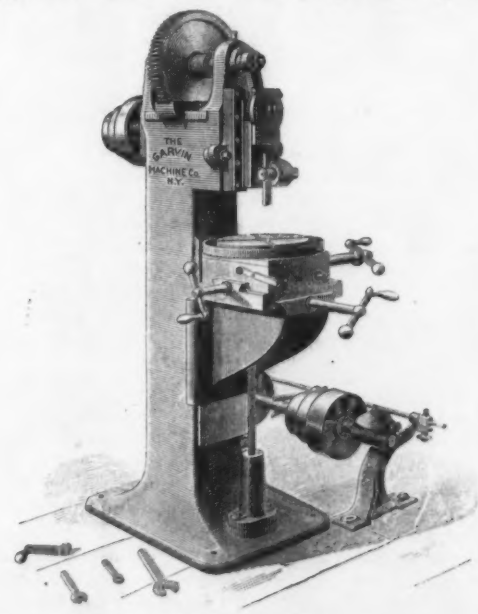
FLUSH WALL SWITCH.

tends around the edge so as to protect the wall from soiled hands when unscrewing the cover, and this at the same time serves to impart a finish to the switch when placed in position. The switch is of interest to architects and others interested in rendering the various appliances used in conjunction with incandescent electric lighting ornamental and unobtrusive, as well as useful.

A New Die Slotter.

A die slotter, manufactured by the Garvin Machine Company, New York, is here shown in perspective and section. For manufacturers and others making numbers of punches and dies there is undoubtedly an advantage in using a slotter.

This machine appears to combine the special features desired in a tool of this kind. The two cross motions and the rotary table provide for following any outline, and the arrangement of handles is convenient and avoids mistaking one for the other. The handle for the rotary table has provision for using dials for dividing purposes, which is convenient for various kinds of work. For small numbers of divisions and for rapid work the worm-shaft can be pulled out, and a lock pin arrangement used for indexing the table, the handle for which is shown at the left hand side. The handle for raising and lowering the knee is conveniently placed on the side of the knee. The stroke of the machine, after due consideration, has been fixed at 2½ inches, which is more than sufficient for the class of work intended, and affords a more solid arrangement than the usual adjustable pin. The



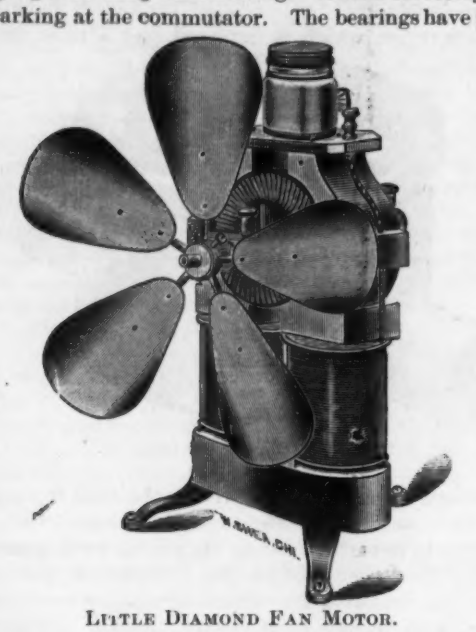
DIE SLOTTER.

work can be brought into proper relation to the stroke by raising the knee, and for thin work, since the cutting is done at the last or slowest part of the stroke, the number of strokes can be increased by means of the cone pulley, which thus fully compensates for any surplus stroke. To give the required draft to the die, the slide for the ram can be swiveled either way, and set by the graduated index, and with this arrangement the draft is the same in every part of the die. The tool block is well adapted to hold special tools.

The tool is cleared on the return stroke by cam arrangement. The tool block swivels on a centre near the lower edge, and at the upper end, carried in a yoke, are two hardened plugs which bear on a cam, which is bushed in to the lower end of the connecting rod and derives a partial rotary movement from the action of the rod, and by this motion locks the tool block. As an instance of what can be done on the machine, a type-writer key 10 inches long, and $\frac{5}{16}$ inch wide at the narrowest part, was machine finished in six hours. A die for armature rings, 5 inches diameter, with 36 notches ⅛ inch wide and ¼ inch deep was done in two hours.

The Little Diamond Fan Motor.

The Little Diamond Fan Motor, shown in the accompanying illustration, is manufactured by Clark & Marshall, 413 The Rookery, Chicago. The motor presents an attractive appearance and is well made. It has a ring armature which gives good ventilation and minimum resistance, thus insuring against dangerous heating. It runs smoothly with no sparking at the commutator. The bearings have plenty



Little Diamond Fan Motor.

of surface and are self-oiling. The motor is designed for two speeds, 800 and 2,000 revolutions per minute. It can be put in operation by merely attaching it to the socket by the plug. The fan is made of polished brass and is twelve inches in diameter.

Railway Current Controller.

In the operation of electric railroads not the least point for consideration is that of facility and rapidity of control of the electric power generators. Until recently the large switchboard has been employed, necessitating extreme agility on the part of the electrician in charge to bring the output of his generators to the desired point, but this plan has been found not only cumbersome but expensive. In order to secure a thorough, effective and rapid control of the generators in an electric railway station, a new device has been gotten up known as the Railway Controlling Table. On this are mounted all the regulating and indicating apparatus in the most compact and convenient manner possible. The framework is of strong bar iron. The lower part of the front of the table and the two ends are of sheet iron ornamented with a molding in relief. The table top, upper part of the front and the upright

RAILWAY CONTROLLING TABLE.

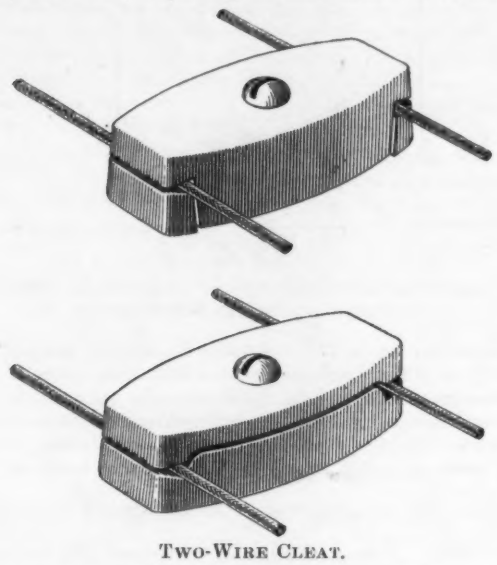
back piece are, in the table illustrated, of polished Tennessee marble, but the more frequent custom is to have these pieces made of polished or plain slate. In front are the dynamo field regulators operated by wheel handles and numbered in reference to the machines they control. On the table are mounted the cross-bar snap switches—a new style of switch recently designed—the dynamo fuse blocks and the equalizing bar switches, one of each for each dynamo, a voltmeter of the Weston type and a voltmeter switch of the regulation pattern.

On the upright back piece are the ampère meters and the galvanometer. The ampère meters are of the standard Edison type. The galvanometer shows when the voltage of the current of one of the generators about to be switched into circuit is the same as that of the other machines already supplying the circuit. It consists of two coils arranged one on either side of a pivoted indicating needle of soft iron. This needle is polarized, it being pivoted within a piece of steel previously magnetized. If the voltage of the current from the generator ready to switch into the circuit is too high or too low, the deflection of the needle indicates the fact, so that the field regulator can be adjusted until the voltage is correct, when the needle presents no deflection.

With this controlling table in the station, the electrician has no difficulty in swiftly regulating his output of current to meet the varying conditions under which the road may be working. With one hand on the snap switch handle and the other on the wheel of the field regulator an almost simultaneous movement is possible, and control is thus immediate. The table shown was intended for four generators and was designed and constructed by the Edison General Electric Company.

A New Two-Wire Cleat.

The accompanying illustration represents the Security cleat which the Security Insulated Company, of 136 Liberty street, New York, is placing on the market in connection



Two-Wire Cleat.

with its well known insulator. This cleat is for two wires, and is strong, serviceable and cheap, besides being neat in appearance. Both front and back views are given. As can be readily seen the cleat will hold any of the usual sizes of wire without injury to the insulation. It is made of the best vitrified porcelain, either glazed or unglazed, as may be preferred.

A Large Electric Locomotive.

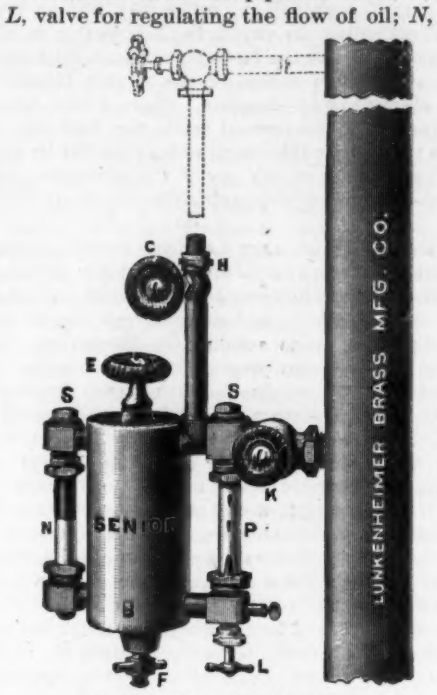
According to the *Elektrotechnischer Anzeiger*, MM. Brown and Boveri, of Baden, are about to build a locomotive which will be one of the most powerful in the world, and quite the most powerful of those driven by electricity. It is to be provided with motors of a total horse power of 1,500, which can be raised to 2,000 h. p. One motor is placed directly on each of the eight axles, and the locomotive is designed for a speed as high as that ordinarily used on steam locomotives. It is expected that it will be ready to be tested by the end of the present summer.

Weighing the Ampere.

The English Board of Trade experts are engaged in determining the exact weight corresponding to the attractive force of an ampère under certain definite, fixed conditions, with the idea of defining a standard by this attractive force, to be called the legal unit. It is stated that their results are well within the limits of the desired accuracy, and that they will be published before long.

The Senior Sight Feed Lubricator.

The accompanying illustration represents the improved Senior sight feed lubricator manufactured by the Lunkenheimer Brass Manufacturing Company, of Cincinnati, O. The more important parts are lettered as follows: *B* is the oil reservoir; *C*, upper valve; *E*, filling plug; *F*, drain valve; *H*, union to connect condenser pipe and valve; *K*, discharge valve; *L*, valve for regulating the flow of oil; *N*, indicator

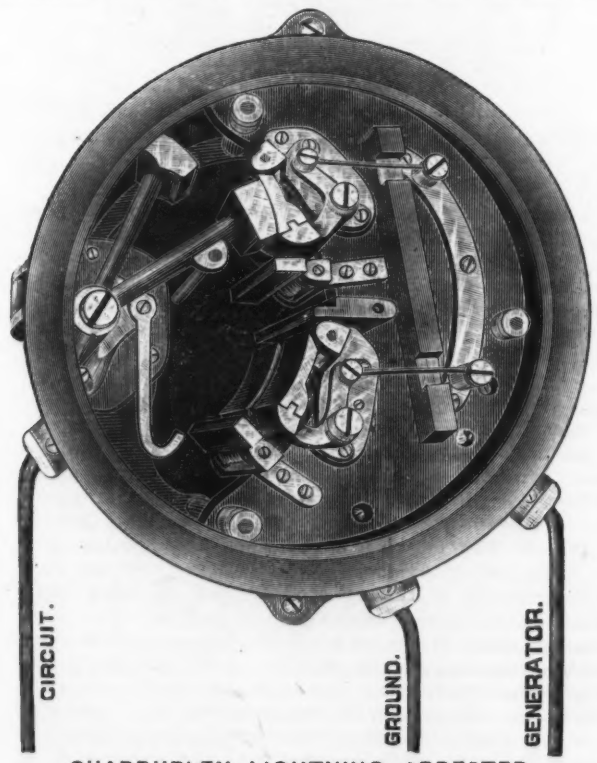


Sight Feed Lubricator.

glass; *P*, sight feed glass and valve to drain and blow out sight feed glass. This lubricator is simple and practical in construction. There is no condensing bulb to freeze and burst. The plugs, *S*, facilitate the replacing and cleansing of the glasses. The shanks on the one-third and one-half pint sizes are threaded for three-eighth pipe, and can easily be attached to small pipes. It is made in eight sizes, from one-half pint to one gallon capacity, and finished in either brass or nickel.

A New Lightning Arrester.

The quadruplex lightning arrester, manufactured by the Utica Electrical Manufacturing and Supply Company, of Utica, N. Y., is represented in the accompanying cut. It is similar in construction to the simplex and duplex arresters of the same company, and is designed for street railway, light and power plants. Four lightning discharges can pass through this arrester before it requires any attention, and the only damage done is the melting of a fuse wire, which can be easily replaced. The contacts are made of bronze metal and very heavy, mounted on slate and inclosed in a watertight iron case, the case being provided with porcelain bushings for the entrance of wires. As there are no magnets used in this arrester, it is adapted for either alternating or direct currents of any voltage.



QUADRUPLEX LIGHTNING ARRESTER.

The Dewey Electric Railway System.

BY W. S. HAYS.

I have read with interest the article on "Dewey's Induction System" in a late issue, and without any desire to detract from the credit due Mr. Dewey will say that a series of experiments were carried on by me on the same line in 1889, but owing to various reasons they were dropped.

My experiments lead me to believe that this will prove a solution of the overhead wire problem and the ideal of electric car propulsion.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

NEW YORK, June 11, 1892.

The general market cannot be called either bull or bear at present, but is decidedly mixed and subject to the ever varying influences which easily change its character. A combination of foreign and home indisposition on the part of the public, political agitation, and the uncertainties of the crop situation are successful in narrowing the market down to a rut of dullness and professionalism indigenous to this season of the year. The leaders in the market are looking for and predicting, from what they consider ominous signs, some changes that will give a pronounced tendency toward a season of activity, but when or what doth not yet appear. Toward the end of the week the demand for call money was better, and speculation a little more brisk. The clearing house rate and rates to borrowers stiffened by one-half to one per cent., but this may still prove only temporary, to give way once more to the easy conditions that have prevailed for so long. First class securities, with hardly an exception, show advances, some of which were quite marked.

The Electric Stocks have passed a very quiet week in New York and Boston, maintaining throughout a strong and healthy condition, in contrast to most of the stocks on the list. Westinghouse stock has had very few sales at old prices. The contract for the World's Fair was evidently discounted, for it has had no influence upon the stock. The company was fortunate in securing a reduction in the amount of the bond, from $1,000,000 to $500,000. Recent contracts secured by the company show that it is a very successful bidder for cash business, especially in railway work. In New York Westinghouse Electric and Manufacturing 1st preferred 7 per cent. cumulative received a bid at 93½, and was held at 95. The E. & M. securities received one sale June 8, at 58. There was scarcely any inquiry as to the remainder of the list. Thomson-Houston and Edison have both been strong and moderately active at good prices. Certificates of the General Electric Company are being signed, and will very soon be ready for exchange for the trust receipts of Thomson-Houston and Edison stocks. The General Electric rights sold down to 10 cents, the majority of them, however, bringing from 10 cents to 30 cents. The success of the first Fort Wayne series is evident from the second dividend of 16 cents, payable July 1. Commercial Cable has been exceedingly strong at $155 bid and $158 asked. This is the level which it has maintained for several weeks.

Western Union.—As predicted in our last week's report, this company declared a quarterly dividend of 1¼ per cent. The financial statement issued in connection therewith shows a net balance of $249,960 for the quarter ending June 30, and for the year ending same date $834,035. The stock, that has been actively traded in, opening the week at 95¼ with very bullish tendencies in anticipation of a dividend. After it was declared it sold off, on active realization sales, to 93⅜ to 94⅜. There was some trading in the bonded securities of the company, the debentures selling on Tuesday at 115 and the sinking funds on Thursday at 106¼. The fiscal year of the company ends with this quarter and the yearly statement shows a surplus of $2,098,798 after the payment of five per cent. dividends on the stock. It is regarded as certain that in September the directors will either increase the dividend to six per cent. or declare a stock dividend, thereby increasing the capital stock to $100,000,000. Its earnings for the next half year should be far in advance of the usual amount, due to politics and the Columbian Exposition. The continued extension of long distance telephone circuits will also come in for a large share of the business which has necessarily heretofore fallen to the Western Union company. Telegraph stock at 95 nets 5¼ per cent., while Bell Telegraph nets 8¾ per cent. on the present market price.

Bell Telephone Stock experienced a sudden and severe fluctuation upon the announcement of a new dividend, because it was less than had been expected. The regular $3 quarterly dividend was declared and an extra dividend of $3 per share. Heretofore the extra dividend in June has always been $6, which together with the four regular dividends made $18 for the year. Previous to the announcement, the stock was selling at 210 and in just an hour declined on very small sales to 197, reacting five points later. Of course the street could not stop to consider the real cause for the decrease in dividend, and the sudden depression was a natural consequence. The explanation is not difficult, and the reason for the action of the directors is patent. The company is said to have sufficient funds to have paid the extra $6 dividend; but since it is intended to issue more new stock very soon, it is manifestly more equitable to all concerned to defer one-half of the dividend until January, so that all the new stock will participate in it, which would not be the case if the usual rule were followed at present. There were as many theories as brokers, some thinking that the nearness of the date for the expiration of the patents rendered it undesirable to continue the 18 per cent. dividend; others, that the company was no longer earning that amount. The latter, however, is hardly credible, for all reports of the company's business give evidence of an increase rather than any decrease in net returns of the business. There is talk in Boston to the effect that the company has foreseen reason for keeping its surplus large and its financial position very strong for the year to come. Some say that it has something to do with the expected litigation over questions involved in the validity of certain European patents which are about to expire, and which is very important to have in continuance in the United States. Another rumor and one which was started last winter at the time that the Associated Press had its falling out with the Western Union is to the effect that the first mentioned organization is figuring with the Bell people for the use of its medium of communication to the exclusion of the Western Union. The very bullish attitudes of Western Union insiders just at this time hardly give color to this report.

Central and South American Cable.—We hear upon good authority that this company has about decided to duplicate its line from Lima, Peru, to Salina Cruz, Mexico. It has not yet decided how to raise the necessary funds, which they expect will be in the neighborhood of $1,000,000, but presumably will do so by means of bond issue. The officers of the company inform us that there will be no increase in the July dividend, reports to the contrary notwithstanding, it being the policy of the company to gradually increase the reserve fund from its earnings. It has enjoyed a very prosperous year, owing to the rapid developments of South American commercial enterprises and the Chilian controversy. Its earnings in consequence show a heavy increase over those of the previous years.

North American.—This company will hold its annual meeting next Wednesday at Newark. It is understood on good authority that there is a reticence on the part of shareholders in sending their proxies, and that a good deal of stock will be represented at the meeting by parties other than the company's officials. In making a second bid for these proxies an official letter concludes as follows: "A comprehensive report is in course of preparation and will be submitted at the annual meeting, and will also be forwarded to each stockholder." This is good news to security holders, inasmuch as the last complete report was issued in 1890; since then little or nothing has been known about the affairs of the company. The stock was exceedingly active during the week around 14½ and 15. It is said that certain large bears have been instrumental in advancing the price in order to unload, while a second rumor is to the effect that the advance is bona fide upon the belief that new people are going into the management, and that new arrangements will be made with electrical interests.

Annual Reports.—The American Bell Telephone Company, of Boston, has filed the following annual report through its treasurer, Wm. R. Driver: Capital paid in, $15,000,000. Assets—Real estate, $933,130; machinery, $4,131; cash and debts receivable, $3,848,735; manufactures and merchandise, $983,870; miscellaneous, $33,180,409; total, $38,950,277. Liabilities—Capital stock, $15,000,000; debts, $2,848,908; reserves, $21,101,368; total, $38,950,277. The Reading Electric Light and Power Company, of Reading, Mass., filed its last annual statement through the treasurer, Lewis M. Bancroft. Fixed capital, $25,000; capital paid in, $12,100. Assets—Land and water power, $31,766; machinery, $7,607; cash and debts receivable, $1,875; total, $41,248. Liabilities—Capital stock, $12,100; debts, $28,011; profit and loss, $1,137; total, $41,248. Taunton Electric Lighting Company, of Taunton, Mass., filed its last annual statement through the treasurer, Thomas Paige. Capital paid in, $50,000. Assets—Land and water power, $1,500; buildings, $6,000; machinery, $12,000; cash and debts receivable, $3,200; miscellaneous, $29,800; total, $52,500. Liabilities—Capital stock, $40,000; debts, $12,500. total, $52,500.

Dividends.—The directors of the Commercial Cable Company have declared a quarterly dividend of 1¾ per cent., payable July 1, to stock of record June 20.

The Copper Market.—The copper market was quiet. Almost the entire lake production is going on contracts which extend through the month of June. The buying for July and August account has not yet set in. Preparatory to this movement, brokers and consumers made an attempt to lower the market by offering small lots below 12 cents. It had only a slight tendency to lower quotations, as the demand for new tonnage is so exceedingly light. Producers fully understand the situation, and are holding firm at 12 to 12¼ cents. The strike in the Osceola mine which occurred last week, and which for a time threatened to extend to other lake mines, seems to have quieted. For a time sales agents in this city were very bearish on the possibility of a spread, and were not inclined to take contracts at any figures offered. This feeling, however, has since been dissipated.

Closing Quotations.—The following were the closing quotations of electric stocks on Saturday, June 11, 1892, in New York and Boston:

NEW YORK QUOTATIONS.

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
American Telegraph and Cable	100	14,000,000	84½	86½
Western Union Telegraph Co	100	86,200,000	94	94½
Commercial Cable Co	100	7,716,000	155	158
Edison Electric	100	15,000,000	..	..
Edison Illuminating Co., of New York	100	4,500,000	86¾	..
" " " Brooklyn	100	750,000	..	..
" " " Chicago	100	750,000	..	..
U. S. Illuminating Co	100	1,250,000	30	35
Edison Elec. Light Co. (of Europe) stock	100	2,000,000	2½	5
Edison Elec. Light Co. (of Europe) bonds	sh	30,000	65	75½
" Ore Milling Co	100	2,000,000	15	20
" Toy Phonograph Mfg. Co	10	1,000,000	....	½
Brush Illuminating Co., of New York	50	1,000,000	40	50
Mt. Morris Electric Light Co	..	500,000	20	40
East River Electric Light Co	100	1,000,000	....	60
North American Phonograph Co	...	6,600,000	5	8
New York Phonograph Co	...	2,000,000	3	4
Automatic Exhibition Co	...	2,000,000	3	6
New England Phonograph Co	...	2,000,000	1¾	2¾

BOSTON QUOTATIONS.

	Par.	Capitalization.	Highest.	Lowest.	Bid.	Ask'd.
Thomson-Houston Elec	25	6,000,000	66	65	65¼	65¾
Thomson Houston Elec. preferred	25	4,000,000	29½	27⅞	27⅞	29
Thomson-Houston Elec.—Series C	sh	40,000	8½	....	8¾	9
Thomson-Houston Elec.—Series D	sh	120,000	7⅜	..	7¼	7½
Thomson-Houston Int'n'al Elec	100	600,000	....	....	240	245
Thomson-Houston Int'n'al Elec—Pfd	100	400,000	....	....	103	105
Thomson Elec. Weld	100	1,000,000	....	....	45	50
Thomson European Elec. Weld	100	1,500,000	10	....	10	..
Westinghouse Elec.—New Com.	..	6,000,000	29⅜	....	29¼	30
Westinghouse Elec.—Pfd.	..	4,000,000	47¼	46⅞	46⅜	48
Fort Wayne Elec	25	4,000,000	12⅝	12½	12½	12¾
Fort Wayne Elec.—Ser. A.	sh	80,000	7½	7⅜	7½	7½
Detroit Elec	10	1,000,000	8½	7¼	7¼	7½
West End St. Ry. Co.—Com	50	7,150,000	75¼	75	75½	75⅝
West End St. Ry. Co.—Pfd	50	6,400,000	89¾	....	....	..
American Bell Tel	100	15,000,000	216½	197	203	203½
Erie Tel. & Tel. Co	..	4,800,000	46	43½	45	45
Mexican Tel. Co	10	1,280,000	....	....	1.02½	1.10
New Eng. Tel. & Tel. Co.	..	10,304,600	56	54	55	56
Tropical Tel. Co	10	400,000	....	....	20	25

NEW INCORPORATIONS.

The Electric Construction Company, of St. Joseph, Mo., capital stock $5,000, has been formed to deal in electric machinery. F. M. Atkinson, C. C. Hyatt and M. M. Crandall, of St. Joseph, are the incorporators.

The O'Neil Electric Company, of Chicago, Ill., capital stock $5,000, has been formed to manufacture and sell electrical apparatus. The organizers are John D. O'Neil, William Edelstein and M. R. Fletcher.

The Alleghany Hotel Company, of Goshen, Va., capital stock $100,000, has been formed to erect electric light plants, electric railways, etc. C. W. Mayer, W. A. Anderson, J. R. A. Hobson and S. M. Taylor are the promoters.

The Lacon Electric Company, of Lacon, Ill., capital stock $16,000, has been formed to construct, maintain and operate an electric light and power plant. I. S. Baldridge, C. C. Travis and Annie J. Travis are the incorporators.

The Hamilton Electric Light and Power Company, of Hamilton, Wash., capital stock $30,000, has been formed to maintain and operate an electric light station. J. L. Warner, H. R. Berdt and G. B. McDowell, of Hamilton, Wash., are the incorporators.

The Forest City Electric Light, Heat and Power Company, of Forest City, Pa., capital stock $1,000, has been formed to supply light, heat and power by electricity. John McLaughlin, W. H. Leek and H. O. Purple, of Forest City, Pa., are the incorporators.

The American Electric Heating Company, of Portland, Me., capital stock $1,000,000, has been formed to manufacture and deal in all kinds of electrical heating apparatus. Edward Jewell, Fred. A. Cook and Samuel B. Jenkins, all of Boston, Mass., are the organizers.

The Suffolk Electric Company, of Portland, Me., capital stock $300,000, has been formed to manufacture and deal in electrical appliances of all kinds. Albert N. Reynolds, Albert W. Rounds, both of Boston, and Henry W. Boyd, of Wareham, Mass., are the incorporators.

The Delaware Company, of Philadelphia, Pa., capital stock $51,000, has been formed to construct and operate an electric railway from Darby and Chester, Delaware County. Edward W. Patton, J. Lee Patton and Samuel Crothers, of Philadelphia, Pa., are the incorporators.

New Kensington Street Railway Company, of Pittsburgh, Pa., capital stock $15,000, has been formed to construct and operate an electric railway in Westmoreland county. S. E. Moore, James P. Anderson and Howard Childs, all of Pittsburgh, Pa., are the incorporators.

The Columbia and Marietta Electric Railway Company, of Columbia, Pa., capital stock $50,000, has been formed to operate an electric railroad in that town. J. K. Sigfried, Pottsville, Pa.; Robert T. Ryan and James A. Ryan, both of Columbia, are the organizers.

The People's Electric Light and Power Company, of Benton Harbor, Mich., capital stock $100,000, has been formed to purchase and sell electricity for light and power. Peter English, John Bell, Benton Harbor, Mich., and Willard W. McDonald, Chicago, Ill., are the incorporators.

The New England Electric Heating Company, of Portland, Me., capital stock $250,000, has been formed to manufacture and deal in electrical heating apparatus of all kinds. Edward Jewell, Boston, Mass.; Arthur B. Smith, and Levi L. Parsons, of Saugus, Mass., are the incorporators.

The Electric Railway Supply Company, of Chicago, Ill., capital stock $200,000, has been formed to manufacture and sell truck wheels and appliances for electric railways, and equipment specialties and power plants. George H. Graham, Francis L. Graham and Thomas Clarke are the organizers.

The El Paso Electric Company, of El Paco, Tex., capital stock $100,000, has been started to operate by means of electric power street railways, and supply light and motive power. George Davis, J. N. Carnes, of Charleston, W. Va.; E. B. Bronson and Peyton F. Edwards, of El Paco, are the organizers.

The Citizens' Passenger Railway Company, of Williamsport, Pa., with a capital stock of $13,500, has been formed to construct and operate an electric railway in the town of Williamsport. Jas. B. Krause, W. W. Champion and A. M. Champion, all of Williamsport, Pa., are the parties interested.

The Portland Consolidated Street Railway Company, of Portland, Ore., capital stock $1,000,000, has been formed to operate street railways and propel cars used thereon by electric or other power. The promoters are Geo. B. Markle, James Steel, R. L. Durham, D. F. Sherman and E. McNeil, all of Portland.

The Shickshinny and Huntington Valley Railway Company, of Huntington Mills, Pa., capital stock $60,000, has been formed to operate an electric railway in Luzerne. E. A. B. Koons, Huntington Mills, Pa.; R. M. Tubbs, Shickshinny, Pa., and C. R. Eberle, Philadelphia, Pa., are the promoters.

The Hopedale Electric Company (incorporated in West Virginia), of Boston, Mass., capital stock $5,000,000, has been formed to manufacture and sell electric batteries, dynamos, motors, etc. E. H. Abbott, Cambridge, Mass.; W. F. Draper, Hopedale, Mass., and Moses Williams, of Brookline, Mass., are the organizers.

The Brighton & Bensonhurst Electric Railway Company has been incorporated to succeed the Sea Beach & Brighton Railway Company. The directors are H. W. Slocum, William Marshall, Wm. N. Dykeman, Denis W. Sullivan, George Hoffman, Wyckoff Vanderhoef, G. S. Jewell, of Brooklyn, and H. W. Slocum, Jr., and Jas. C. Bergen, of New York.

AFFAIRS OF THE COMPANIES.

Farmington, Mass.—The Farmington Electric Light and Power Company has been taken on a mortgage by the Edison General Electric Company, and Mr. Eugene F. Carpenter has become manager of the station.

Richmond, Va.—The stockholders of the Johnston Safe Automatic Electric Disconnection Company held its annual meeting on June 3d. All the old directors were re-elected. The affairs of the company are reported to be in a satisfactory condition.

New York.—A judgment for $2,108 has been entered against th Gibson Electric Company, of 74 Cortlandt street, in favor of Henry D. Donnelly, on promissory notes and for services as counsel. The company was incorporated on Feb. 5, 1886, to manufacture storage batteries. Its factory at Chatham, N. Y., was destroyed by fire last Fall.

Mr. J. P. Altenberg has succeeded in connection with Cincinnati and Louisville bankers and brokers in reorganizing the Citizens' Electric Light and Power Company, of Louisville, Ky., on a half million dollar basis. The company now has 3,000 Thomson-Houston lights in operation. Arrangements have been made to rebuild the plant on a new site, the new site to have a capacity of 7,500 incandescent and 200 arc lights and 250 h. p. for supplying motors.

The Edison General Electric Company has issued the following letter dated May 31, and signed by Chas. D. Shain, district manager: "Owing to the fact that our company will open new books as of June 1, we have to request that you make settlement of your account up to that date, independent of subsequent transactions. You are also requested to remit at the earliest possible date, in settlement of account to June 1, and thus avoid any possible confusion thereafter."

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, June 13, 1892.

Mr. E. H. Cutler, of the Elektron Manufacturing Company, of Springfield, made a trip to New York last week.

Mr. W. H. McKinlock, of the Central Electric Company, of Chicago, made THE ELECTRICAL WORLD a pleasant call last week.

Mr. J. D. Bishop, who was recently electrical expert to Messrs. John A. Roebling's Sons' Company, has joined the staff of the Safety Insulated Wire Company, of 234 West Twenty-ninth street, New York City.

Mr. H. H. Brooks, the efficient general manager of the American Circular Loom Company, of Boston, was in New York this week consulting with Messrs. Doubleday, Mitchell & Co., the agents of his company.

Mr. Edwin R. Weeks, of Kansas City, was in New York on Monday, and left the same evening for Boston. Mr. Weeks is a busy man and his visits East are always too brief and too far apart, for he has many friends in this section.

The Mather Electric Company, which has received the contract for lighting the Mechanics' Fair Building, Boston, has placed an order with the Electric Construction and Supply Company, of 18 Cortlandt street, for 150 "Ward" arc lamps.

Mr. P. L. Rose, of the Rose Electric Light Supply Company, of St. Louis, has been in the city for the past few days establishing a New York office. It has been decided to locate at 135 Liberty street, in the Electrical Exchange Building, and Mr. H. F. Gray, well known to the electrical trade, will represent the company.

New York.—The Department of Electricity of the Brooklyn Institute held its annual meeting on June 2 in Association Hall. After the lecture by Prof. E. J. Houston the following officers were elected: President, James Hamblett; First vice-president, William A. Barstow; second vice-president, James P. Wintringham; secretary, R. J. Murphy; treasurer, R. M. Baylis.

A Champion Pistol Shot.—The opening contest for the Winans trophy, emblematical of the amateur championship of America in revolver shooting, under the supervision of *Forest and Stream*, has been decided in favor of Dr. Louis Bell. He used a Smith & Wesson revolver, 44 calibre, 6½ inch barrel, weighing two pounds seven ounces. The trophy is to be held subject to a challenge for the term of two years, after which it will become the winner's personal property.

Dr. Louis Bell, who resigned his position as editor of THE ELECTRICAL WORLD on the first of March last to take an active part in the commercial development of the transmission of power, has joined the forces of the General Electric Company, and will have charge of the engineering work which will come up in connection with the transmission of power on a large scale for other than railway purposes. He will be located, for the present, at Lynn, Mass., where he will be associated with Messrs. Knight and Parshall. This is the branch of electrical work in which Dr. Bell takes the deepest interest and in which there is now the greatest field for an original designer to exercise his engineering abilities. In the near future some very heavy work will undoubtedly be done in the transmission of power, and, as might be expected, the General Electric Company is preparing to take hold of this great and important branch in the same vigorous manner in which it developed the enormous electric railway business which it now controls. In the engineering department of the General Electric Company Dr. Bell will find some very genial colleagues, who are at the same time most excellent electrical engineers, as is well shown by the character of the Thomson-Houston apparatus which has been designed and built under their direction. L. H. H.

ALBANY, June 11, 1892.

An injunction has been served on the Troy & Lansingburgh Railway Company for the purpose of keeping it off of the property of the Union Railroad Company.

The report of the Troy City Railroad for the first quarter of the year shows the following: Gross earnings, $7,941; operating expenses, $7,708; fixed charges, $913; loss from operation, $351; cash on hand, $123.

To Adopt the Trolley System.—The State Railroad Commission gave a hearing May 16 on the application of the Binghamton & Port Dickinson Railroad Company for permission to use the electric trolley system on certain parts of its line.

The Report of the Troy & Lansingburgh Railway for the quarter ending March 31 shows the following: Gross earnings, $86,144; operating expenses, $47,570; net income, $31,149. It cost $61,083 to operate the road in the quarter of 1891 and the net income was $11,199.

Acting Manager Hawley, of the Hudson River Telephone Company, informs THE ELECTRICAL WORLD correspondent that it will be late in the fall before the new building will be ready for occupancy. The new switchboard will not be completed until after Aug. 1. The new masts from which the wires will be distributed will be erected at once. The laying of the cables will be begun the first of June. The preliminary work of threading the conduits with wires has already begun. The new plant will be one of the most perfect in the country.

The electric gas lighting plant in the Cathedral of the Immaculate Conception is completed and gives desired satisfaction. A very striking effect is produced and the architectural beauties of the cathedral are displayed to full advantage. Mr. Fred Newman had charge of the work which has been going on for over eight weeks. On two arches in the sanctuary are over 300 burners, and in the whole church there are over 1,000 lights. They are lighted with 1½ inch Ruhmkorff spark coil, with Edwards burners and condensers. Two 10-cell batteries furnish the electric current. Electricians are at work connecting the main organ with the two chancel organs, so that the organist can play all together from his position before the main altar, or each one separately. This is said to be the only instance in the country where three organs have been electrically connected.

An Electrical Stamping Machine will be put in operation in the post-office. The machine is the invention of Mr. George W. Hey, of Syracuse, and Mr. M. J. Dolphin, of New York, and will cancel the stamps and put the city postmark on all letters and postal cards received at the local office. It is estimated that the machine will do the work of 12 men. It is operated by a one-quarter horse-power motor and combines the features of effective cancellation, uniform and legible postmarking and an accurate registry of the number of letters and postal cards that pass through it. The International Postal Supply Company is the owner and manufacturer of the apparatus and the capital of the company is $2,000,000. The United States government has made the contract to rent enough machines to supply all the first and second class post offices in the country at an annual rental of $400 a year. Between 8,000 and 9,000 machines will be required. R. V. T.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., June 11, 1892.

The H. E. Swift Manufacturing Company, of Boston, has removed its office and factory to No. 1 Hartford street.

Albert and J. M. Anderson, manufacturers of the well-known Boston trolley and Etna insulation line material, are doing a very satisfactory business.

The Newburyport Car Company is finishing its order for street railway cars for Fall River, and will soon begin the manufacture of closed cars for fall and winter use.

The Natick Cochituate Street Railway has contracted for four car equipments of 25 h. p. motors of Westinghouse single reduction type for their road. It proposes to extend its line to Saxonville, making nearly 10 miles of road.

Dedham, Mass.—Over 800 citizens of Dedham have signed a petition asking the selectmen of the town to grant a franchise for an electric street railway. Two companies, the Suburban and the Old Colony, are seeking to obtain the privilege.

The Sampson-Cordage Company has recently enlarged its plant. It finds the demand for its Sampson arc light and trolley cord far heavier than anticipated. This company also manufactures cords specially suited for covering field magnets.

The Shawmut Fuse Wire Company reports that its business is steadily increasing It claims that its wire is smoothly and accurately drawn and its links are all tested by the Massachusetts Electrical Engineering Company before being offered for sale.

Thos. J. Hind, of Boston, has secured the contract for roofing the three new buildings for the Thomson-Houston Electric Company at West Lynn. The buildings comprise about 110,000 square feet, and will be covered with Warren's natural asphalt "Anchor Brand" roofing.

The new marble arc switchboard recently built by the Thomson-Houston Electric Company, and intended for the station of the Narragansett Electric Company, in Rhode Island, will now be sent to the World's Fair at Chicago. It is the largest board of the kind ever constructed.

The Chapman Valve Company has recently introduced a new steam valve with bronze seats for superheated and high pressure steam made from heavy patterns supplied with by-pass outside screw and yoke with self-packing steel spindles. These valves are guaranteed to withstand a constant live steam pressure of 125 to 250 pounds per square inch and are especially adapted for electric plants which are carrying a steam pressure of 125 pounds and upward.

Concord, N. H.—There was an important conference recently held by capitalists of Massachusetts and New Hampshire interested in the building of an electric railroad from Epsom, on the Suncook Valley line, to East Norwood, a distance of about 11 miles. Among those present were President Smythe and several other directors of the Concord & Montreal Railroad; John J. Bell, of Exeter; Ira N. Blake, of Northwood, and a representative of the Thomson-Houston company. The project was thoroughly discussed, and all present regarded the scheme as a very feasible one. A portion of the route is over the new highway that was opened last year between Epsom and Northwood Centre. W. R. W.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, June 11, 1892.

Mr. William H. McKinlock, president of the Central Electric Company, has just returned from New York.

The Electrical Engineering & Supply Company of St. Paul, Minn., is issuing a handsome pocket supply price list.

Dr. John McKinlock, of the Central Electric Company, has recently been confined to his house by sickness, but is again at his desk.

Mr. George Mayo, of the Rockford Electric Manufacturing Company, was in Chicago on Thursday en route from Independence, Ia., to St. Louis.

Mr. Frank A. Wunder, formerly of the Western Electric Company, is now associated with the Chicago office of the Fort Wayne Electric Company.

Mr. L. Chapin, No. 74 State street, Norwalk, O., is securing information regarding the cost of constructing an electric railway line to connect neighboring towns.

Mr. Charles E. Gregory, No. 313 Canal street, Chicago, has secured orders for five arc and seven incandescent machines since opening up his "trading store."

Mr. C. M. Turnquist has opened an office in room 23 Lakeside Building, Chicago, and will handle electrical specialties and also contract for interior wiring.

Mr. S. McClanathan, secretary and treasurer of the Mica Asbetite Insulating Company, of Denver, Colorado, was in Chicago this week en route to Kansas City.

The Butler Manufacturing Company, of 70 West Washington street, Chicago, is supplying the electrical trade with metal specialties, such as tin shades, etc.

The Electrical Supply Company, Chicago, has issued a special catalogue, No. 245, in which are illustrated and described the electrical specialties manufactured by John R. Fletcher.

The Sunbeam Incandescent Lamp Company, Chicago, are in receipt of renewal orders for incandescent lamps that are the best indorsements they could possibly desire regarding the efficiency and value of the Sunbeam lamp.

Mr. William McVay, of New York, gave a lecture on "What Electricity Is" before an interested audience in the church parlors of the Third Unitarian Church, corner of Monroe and Laflin streets, Chicago, on Thursday evening, June 9.

Reduction of the World's Fair Lighting Bond.—The bond into which George Westinghouse was obliged to enter, in conjunction with the contract for furnishing the Exposition with electric lights, was reduced yesterday from $1,000,000 to $500,000. Mr. Westinghouse has furnished the bond.

Mr. B. F. Sunny, who was Western manager of the Thomson-Houston company, has taken charge of the interests of the General Electric Company. Mr. John Beggs, who was in charge of the Edison company, has gone east, and his assistant will serve in the same capacity with Mr. Sunny.

The Electrical Supply Company, Chicago, displayed the bulletins received over their private wire from Minneapolis during Friday afternoon. Thus the thousands who pass the corner of Randolph and Michigan avenue were enabled to keep track of the balloting as it proceeded by the bulletins shown in the window.

The Chicago Fire Cyclorama.—The members of the American Institute of Electrical Engineers, who visited this realistic painting of the fire that destroyed over two hundred millions of property and rendered homeless a hundred thousand people in a day, were impressed with the perfect reproduction of scenes familar to those who resided in Chicago in 1871 and witnessed the terrible sight. F. De L.

Answers to Correspondents.

Readers are invited to send discussions regarding, or answers to the queries published in the column above, or with regard to any other live questions on electrical subjects. In answering questions please refer to them by their serial number. Correspondence must be accompanied by the real name and address, not necessarily for publication, but as a guarantee of good faith. Names of correspondents will be printed in full unless otherwise requested. All correspondence should be as brief as is consistent with clearness. THE ELECTRICAL WORLD assumes no responsibility for the opinions expressed by correspondents.

[72.] Refer to the Thomson-Houston company. H. W.

[82.] It would hardly be practicable to charge any form of storage battery now made at a central station and transport it any great distance for the use of consumers. A. B.

[88.] It would not be possible to run six 50-volt arc lamps and two 16 c. p. 100-volt incandescent lamps on a 500-volt street railway circuit, as the arc lamps require 10 ampères, and the incandescent only ½ ampère. Ten-ampère lamps of 100 volts are probably obtainable in the market, but they would give from 250 to 300 candles, and when thus connected they would probably flicker considerably. L. M.

[90.] You could construct a cheap form of galvanometer and use some of the methods given in the text books. One who has had experience can estimate with considerable accuracy the voltage of a circuit by the brilliancy of an incandescent lamp inserted, but of course this method can only be used where the voltage to be measured is somewhere near that of the lamp employed. C. D.

[91.] You could not charge the cells from a 112-volt circuit by connecting the negative wire to the cells and thence to ground unless the positive wire of the circuit is grounded. The ground has nothing to do with it. By connecting directly to the mains, using proper resistance to cut down the volts, the cells could be charged from such a circuit, but it would not be an economical method, unless there were quite a number of cells. H. K.

[92.] With water power at a distance of 12 miles from the centre of distribution you would hardly get satisfactory results with a direct current of 600 volts. Either the loss in the line would be excessive or, if sufficient copper was used, the cost very great. C. D.

[95.] In actual practice one watt represents not far from 1½ c. p. in an arc light, but the conditions vary so that it is impossible to state any exact value. A. B.

[96.] On the ordinary alternate current transformer system the calculation of the candle power from the watts would be practically the same as with direct currents. P. O.

[98.] There would not be sufficient leakage from the flexible cords around gas fixtures to have any appreciable effect on a meter. L. M.

[99.] One way of making a selenium cell is to wind two separate strips of platinized silver wire around a cylinder of hard wood, taking care to maintain them at a constant distance apart, so as to avoid contact between them. The space between these wires is filled with fused selenium, which is allowed to cool gradually. If one of the electrode faces is exposed to light, and the other kept in darkness, a difference of potential is obtained. E. H.

[100.] Quite extensive experiments with selenium cells have been made by Von Uljanin. C. D.

News of the Week.

THE TELEPHONE.

Morgan, Vt.—Arrangements are being made to have a telephone connection at this place.

Deal's Island, Md.—A telephone is to be constructed from the island to Princess Ann. Address the Town Clerk.

Onondaga, N. Y.—The Central Division office of the American Telegraph and Telephone Company has been destroyed. Loss on machinery and instruments, $1,500.

THE ELECTRIC LIGHT.

Omaha, Neb.—The Fred Kreug brewing plant will have an electric plant and furnish lights and power for the factory.

New Ulm, Minn.—The Eagle Roller Mill Company expects in a short time to establish an electric light plant in its factory.

Mobile, Ala.—The Electric Light company proposes to increase its capital stock, and will enlarge its electric and steam plant.

Baltimore, Md.—The American National Bank, which is in course of erection, will be lighted with both gas and electricity.

Coatesville, Pa.—The Coatesville Electric Light, Heat and Power Company has not yet determined upon the location of its plant.

Louisville, Ky.—The Citizens' Electric Light Company is to be re-organized and the plant enlarged and improved. Address W. T. Halsey.

Uxbridge, Mass.—The Uxbridge and North Bridge Electric Company intends to enlarge its present building, and will add new machinery.

Westport, Mo.—The Council will submit to the people a proposition to vote $8,000 bonds for a city hall, water-works and electric light plant.

Rochester, N. Y.—Common Council Lamp Committee has rejected bids for lighting the city and requests more bids, which will be opened until June 13.

Livermore Falls, Me.—The largest paper manufacturing concern in the town proposes to erect a plant and light and run the factory by electricity.

Township, N. J.—The Nutley Electric Light, Heat and Power Company is rapidly completing its plant. It is expected that the city streets will soon be lighted.

New York.—A number of resolutions for electric lights in various parts of the city have been adopted by the Common Council and the lights will soon be erected.

Columbia, S. C.—The Council is considering the question of procuring a plant for the city. The city engineer has been employed to aid them in the enterprise.

Toulon, Ill.—The electric light investigating committee has examined the various methods of lighting and recommended the arc light as the best adapted for street lighting.

East Greenwich, R. I.—A meeting will be held June 14 to vote on the question of issuing $20,000 bonds, proceeds to be used to buy, own and operate an electric plant.

Hallock, Minn.—An electric light franchise has been granted by the Council to Kelso & Beacon, of this city, and an electric light plant will be put in and in running order in 60 days.

Abington, Ill.—Mr. J. T. McAllister, who has the contract for the erection of the electric light station, reports the work in progress. The building is to be completed by the first of July.

Cincinnati, O.—It looks as if the new electric light works would be established here. The men who back the enterprise claim that they already have a sufficient number of subscribers.

Meredith, N. H.—A. W. Ives, of Boston, representative of the Thomson-Houston Electric Company, has been inspecting the advantages for establishing the electric plant in the village.

Philadelphia, Pa.—The Brush Electric Light Company will apply for permission for opening the streets and laying conduits on Walnut, Chestnut, Arch and other streets as soon as plans can be furnished.

McKeesport, Pa.—The Belle Vernon Water Company and

the Electric Light Company, two new companies chartered with a capital of $1,000 each, are preparing to establish and commence the building of a plant.

New York, N. Y.—The Lexington Avenue Opera House on Fifty-eighth street will make many improvements. Electric lighting will be used throughout; ventilation will be insured by means of an electric motor.

East Greenwich, R. I.—A committee has been appointed to secure information regarding the cost of putting in and operating an electric light plant. Action will be taken upon their report at the August town meeting.

New Bedford, Mass.—The Jenney Star Electric Company will enlarge its plant by adding new machinery for the purpose of manufacturing arc lamps for the Suffolk Electric Company, of Boston.

Rye, N. Y.—The residents of the second and third districts are desirous of having the streets lighted by electricity. It is thought that 30 lights will be sufficient. No action, however, will be taken until $80,000 has been subscribed, part of which is now in hands of committee.

Coatesville, Pa.—The Coatesville Electric Light, Heat and Power Company is now deciding on the location of its plant. The company has received bids for the dynamos, engines, wiring, etc., and will be ready to go ahead with the work as soon as the location can be secured.

Marietta, O.—A company has been formed to furnish electric light and power and has made an application for a charter. The incorporators are: Barr Spangler, Amos Bowman, H. B. Cassel, E. L Reinhold, H. S. Rich, A. D. Wike, L. E. Weimer, Col. D. B. Case, Dr. G. W. Reich and Prof. Haldeman.

Fort Edward, N. Y.—The Fort Edward Electric Company is now enlarging its plant. It has already ordered a new dynamo of 800 lights capacity, a 130-h. p. engine and a 150-h. p. boiler. This will give the company a total capacity of 1,000 lights. Work on this new addition has been commenced. The company has about 300 additional residence lights to put on its circuit.

Philadelphia, Pa.—The sub-committee of the Council's Electrical Committee having charge of the ordinance authorizing the Edison Electric Light Company to lay conduits in the streets has again decided to report the ordinance favorably to the general committee. The company is required by the ordinance to lay conduits for the city to the extent of at least $25,000 a year, which shall be under the exclusive control of the Electrical Bureau and shall be the property of the city. The company is prepared to go ahead with the work as soon as the ordinance is passed.

THE ELECTRIC RAILWAY.

Pueblo, Colo.—It is proposed to construct a street car line to the new East Side Park. Benj. Mattice and W. T. Booth are interested.

Delaware, O.—A company with capital of $60,000 has been organized to construct and operate an electric street railway.

Bridgeport, Conn.—The horse railway company will lay new tracks throughout the West End as soon as it gets permission to use an electric system on the line.

Haverhill, Mass.—At a town meeting held at Groveland it was unanimously voted to allow the Haverhill & Groveland street railway to use electricity to propel its cars.

Mt. Washington, Pa.—The Hilltop, Grandview & Mt. Washington Traction Company proposes to extend its lines to the Union Station. W. B. Lupton is president.

Penacook, N. H.—The Electric Railway Company proposes to build an extension to the road one mile along the banks of the Contoocook River to a new park which has just been purchased.

Toronto, Can.—Mr. Evertett, general manager of the street railway, states that he will change 55 miles of road to the trolley system if the City Council will do its share of street improvements.

Jersey City, N. J.—The Jersey City & Bergen Railroad Company will shortly award the contract for the construction of the one-story 164 by 110 foot brick building to contain new machinery to propel the company's cars by electricity. Engineer Belknap has prepared plans.

Chester, Pa.—The Chester & Darby Electric Railway Company, capital $50,000, will construct a line through Chester, crossing the bridge and running through Darby. Edward Miller and Chas. H. Warren, Fall River, Mass., and Franklin S. Holmes, Brooklyn, are the promoters.

Brooklyn, N. Y.—John Delmar and Louis C. Berman have applied for a franchise for the privilege of operating an electric surface railroad through Union street from Hamilton Ferry to Prospect Park. Gen. Stewart L. Woodford and Cornelius Donnolon will also present a like petition.

Albany, N. Y.—The directors of the Albany Railway Railway Company will hold a meeting June 29 for the purpose of increasing its capital stock to $500,000. It is proposed to make the power house on Troy division a repair shop and add generators and motors to station on South Pearl street.

Troy, N. Y.—The poles for the electric lines of the Troy City Railway Company have been erected and the work of stringing the wires is about completed. Cars are expected to be running to Albia on July 4. The Gilbert Car Company has completed six new box cars and six open cars for the road.

Brooklyn, N. Y.—Two new schedules have been introduced on the Fort Hamilton & Hamilton Ferry Line of the Brooklyn City Railroad, in order to overcome the delays now occasioned by the Hamilton Avenue bridge. It is estimated that on Sundays 50,000 people are carried to Fort Hamilton by this road.

Buffalo, N. Y.—The Buffalo Railway Company is pushing forward its improvements as rapidly as possible. The company has now about 90 electric cars in daily operation, and 20 in reserve. As soon as the Main street line is completed this number will be increased to 120. The work on the Main street track is all completed, except some special iron work which has not yet been received. The Seneca street extension is fast nearing completion.

The Calumet Electric Street Railway Company ran the first car over the line connecting with the cable at Seventy-first street, Chicago, on Decoration Day. Cars will run every ten minutes on Sundays and at intervals of fifteen minutes on other days. The power house is at Stony Island, but a new power house and car barn are building at Burnside. The cars are driven by 40-h. p. Detroit motors and power is furnished by Thomson Houston and Rae generators. The track is laid with 78-pound Johnson rails on 8-foot oak ties.

Toronto Junction, Ontario.—The work on the City & Suburban Electric Street Railway has actually commenced, and bids fair to be completed within the specified time. About 80 men are now employed in the work, and 100 more will soon be put on. Mr. Barr, the manager of the construction, also proposes to erect a large power house capable of generating 10,000 h. p. to supply the factories. As the town is in need of incandescent lights for interior lighting it is probable that the company will make a bid for a franchise for that class of work.

The Electric Railway Company of the United States is an organization formed to experiment with electric motors. Stephen D. Field, a nephew of Associate Justice Field, of the United States Supreme Court, is conducting experiments at present especially with a view to adapt some electric motor for use on the elevated railways. On Thursday there was a special meeting of stockholders at No. 1 Broadway and the following trustees were elected: Cyrus W. Field, Cephas Brainerd, Stephen J. Field, the Rev. Henry M. Field, Edgar M. Marble, Stephen D. Field, Charles S. Coye, Phillip P. Harris and John H. Dey.

New York, N. Y.—Mr. Mead presented to the Board of Aldermena petition from the Houston, West Street & Pavonia Ferry Railway Company, asking permission to connect the Ninth Avenue surface road with the Sixth Avenue road by a spur through Fifty-third street. This road is also controlled by the syndicate of which John D. Crimmins is president. New York & South Beach Railway's directors have been authorized to issue six per cent. 33-year bonds in amount not to exceed $150,000, the proceeds to be used in building and equipping the proposed road, which will be three miles long and connected with the lower terminus of the Staten Island Rapid Transit road. The motive power has not yet been decided on.

LEGAL NOTES.

Telephone vs. the Electric Railway.—An injunction has been served on the Electric Street Railway Company, of Hornellsville, N. Y., by the Bell Telephone Company, and the work of construction of the road has come to a standstill. The telephone company charge that the construction men have totally disregarded the right of the telephone company granted by the city in May, 1887, and have seriously interfered with the working of the telephone wires. The telephone company demands that the railroad company provide them with poles whereby their wires can be erected above the trolley wires. The railroad company contend that their franchise is superior to that of the telephone company. The differences will be fought in the courts.

Suit Against a Parent Company.—The Kansas City local electric lighting company, of which Mr. E. R. Weeks is manager, has brought suit in the United States Circuit Court of Wisconsin against the Thomson-Houston Electric Company for $210,000 damages for breach of contract. The Kansas City company is a licensee of the Thomson-Houston and acquires the exclusive control of the Thomson-Houston apparatus for two counties. Recently the Thomson-Houston licensed the Jenney company to use its regulator in these two counties; the Jenney company sold machines to the gas company, Kansas City, equipped with Thomson-Houston regulators, and the gas company became an active competitor of the electric light company, hence the suit. The answer of the Thomson-Houston company has not yet been filed.

The suit of Webster Gillett and others against the American Union Telegraph Company to recover $100,000 damages for breach of contract was tried before Judge Wallace on June 3. A contract was made between the plaintiffs and defendant in 1880, whereby the American Union Telegraph Company took one-half in a certain patent relating to telephoning, and was to pay the plaintiffs 50 cents for each instrument manufactured and used by it. A clause in the contract prohibited either party from transferring its right without the written consent of the other side. In 1881 the American Union Telegraph Company consolidated with the Western Union, and under contract with the Bell Telephone Company the Western Union was restrained from using any other telephone than the Bell instrument. The plaintiffs complain that by the consolidation the American Union Telegraph Company had transferred its rights to the Western Union, but Judge Wallace held that such could not be construed into a transfer. He accordingly directed a verdict of six cents for the plaintiff.

MISCELLANEOUS NOTES.

"The Digest of Electrical Patents" is the title of a new publication of which we have received advance specimen pages. It will be issued monthly under the direction of Mr. Ralph W. Pope, Secretary of the American Institute of Electrical Engineers, and will embrace a synopsis of each patent relating to electricity granted during the month. These patents are arranged in classes and sub-classes, with numerical and alphabetical indices.

The Carpenter Electric Storage Company, of Denver, Colo., has presented the School of Mines with a 61-cell storage battery, valued at $600, which will be used for practical instruction and lighting purposes at the school. A syndicate, of which W. A. Russell, of Lawrence, Mass., is at the head, has completed the purchase of the Garvins' Falls property in South Concord and Bow, and it is stated that in 60 days the city proper will be supplied with electric power from that plant.

Industrial and Trade Notes.

Don C. Waters, manager of the Lake Girard mica mines, reports a steady and increasing demand among dynamo manufacturers and he is now prepared to supply direct to users mica cut to given dimensions or in a rough split state.

The Ideal Engine still continues to meet with favor. A 60-h. p. Ideal was recently shipped to the Chapman Electric Light Company, of Dublin, Tex., and another of 35 h. p. to Sanger Bros., of Dallas, Texas, for an isolated plant. The manufacturers of these machines are A. L. Ide & Son, Forth Worth, Tex.

The Link Belt Engineering Company has recently issued an instructive catalogue on "Power Transmission by Manila Rope." It contains a great deal of useful information and many interesting illustrations showing the wide application of manila rope to the transmission of power and giving evidence of its wide spread use.

The Central Electric Company, of Chicago, is putting on the market a very compact little fan motor, made in sizes ⅛, ¼ and ½ h. p. These motors can be used on desks, and can be attached to the wall by a simple device, the whole being the product of the Interior Conduit and Insulation Company, for which the Central Electric Company is general western agent.

The Electric Appliance Company reports large sales of Meston alternating current fan motors. Although the season can hardly be said to have opened up they are nevertheless considerably behind on their orders, and have had a demand far in excess of their expectations. The demand for canvas jacket wire is also very heavy and the factory is crowded to its utmost capacity.

The Ideal Oil Refiner is meeting with great success. Some of its latest sales are: The Leader Publisher Company, Pittsburg, Pa.; Robt. H. Thorburn, Rapid City, S. Dak.; Stanley Rule and Level Company, New Britain, Conn.; Carnegie Bro. & Company, Braddock, Pa.; Lakewood (N. J.) Electric Light Company; National Soldiers' Home, Dayton, O.; Crooke, Horner & Company, Baltimore, Md.

The Chicago Electric Wire Company is sending out samples of its insulated wire. This company manufactures solid conduits for all kinds of electric work and stranded cables for submarine and underground work, both in plain, braided, leaded and armored styles. The quality of the insulation seems to be very excellent and the most severe bending fails to develop any cracks or imperfections.

The Railway Equipment Company, Chicago, reports for the last week orders for the complete equipment of roads in New Haven, Conn.; Brooklyn, N. Y.; Baltimore, Md.; Evansville, Ind.; Chillicothe, O.; Pittsburgh, Pa.; Hamilton, Can.; Augusta, Ga.; Kokomo, Ind.; and Put in Bay, O. They have also made during the same time large sales for extensions of present roads. The business of this company is constantly increasing.

Queen & Co., of Philadelphia, are just issuing a revised price-list of their "Magnetic Vane" ammeters and voltmeters, in which two forms are given, one with brass and the other with iron cases. The difference in price is occasioned only by a corresponding difference in the material used, and external finish, for both types are calibrated to the same degree of accuracy. These instruments are extensively employed for switchboard purposes, and enjoy an excellent reputation. As decided changes in appearance and prices have been made it will be well for interested parties to obtain a copy of the special descriptive circular No. 330.

A Curious Way of Advertising.—In the show window of a a store in Wilmington there is a glass case in which is a pivoted Crocker-Wheeler motor with a fan, and about two pounds of feathers. When the motor is in operation it revolves completely around a circle, throwing a strong current of air and causing the feathers to fly around in all directions. The crowd about the window is so great that it requires two policemen to keep them away, and as a natural result the dealer is growing rich from his sales of motors. It is reported that the Crocker-Wheeler people are receiving more orders for these pivoted motors than they can fill.

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

Molds for casting battery zincs are made of iron and steel. We have just completed sets for the "D'Infreville Patent Wasteless Zinc," costing over $40 each. H. Brooke, 44 Barclay street.

Thirty-five-light, 2,000-c. p. American arc dynamo in good condition, for sale at a bargain; also 750-light Westinghouse alternator, with station appliances. Address E. T. Pardee, 10 Butler Building, Syracuse, N. Y.

Burlington Route—New Service.—A through Pullman sleeping car, Chicago to San Francisco, is a feature of the Burlington's new service. This car leaves Chicago daily on the fast train at 1:00 P. M., and runs via Denver, Colorado Springs, Leadville, Glenwood Springs, Salt Lake City and Ogden, arriving in San Francisco at 11:45 A. M., less than four days *en route*.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

[In Charge of W. A. Rosenbaum, 177 Times Bldg., N. Y.]

U. S. PATENTS ISSUED JUNE 7, 1892.

476,236. Electro-Magnet; Andrus D Ayres, Kalamazoo, Mich. Application filed Sept. 15, 1891. The combination of a series of paramagnetically incased coils provided with a series of magnetically divided core-armatures, the armatures being bound together and each armature arranged to form portions of particular magnetic circuits, and a suitable commutator so arranged that the combined armatures are made to partake of the action of the series.

476,240. Railway Signaling System; Frank P. Benjamin, New York. Application filed Sept. 5, 1891. In a system of railway signaling, a signal, a locking device, and devices along the track at opposite ends of a section, automatically operated by a passing train to work the lock without changing the position of the signal when the train enters and leaves the section, so that the signal cannot be made to indicate "safety" while the train is on the section.

476,292. Apparatus for Trimming Carbon Points; Philo Moses, Fremont, O. Application filed June 25, 1891. In an apparatus for trimming carbon points, a frame-work, and a stationary knife-carrier fixed thereto, in combination with a sectional carbon-holder adapted to open by gravity, a shaft carried by the frame-work, and eccentrics carried by the shaft and operating to close the carbon holder and raise it into engagement with the knives.

476,296. Electric Battery; Richard P. Osgood, Methuen, Mass. Application filed Jan. 18, 1892. In an electric battery, the combination of a containing jar, a porous cup therein, two perforated copper plates respectively disposed in excitants on opposite sides of the cup and connected by straps or other means, a binding post on said connection, a porous cup within the inner copper cylinder, a zinc plate provided with a binding post, disposed within said inner porous cup, and an excitant for said zinc.

476,311. Electrical Governor; Mark A. Replogle, Mattawana, Penn. Application filed Dec. 12, 1890. In an electrical governor, the combination of an electrically connected standard, a tripodal mercury retaining vessel revoluble in a horizontal plane therein, an insulated electrical connection with the mercury in the middle tube at lower speed than normal, an independent electrical connection with the mercury in the outer tube at lower speed than normal, an independent electrical connection with the mercury in the outer tube only at speed above normal, insulated collectors separately connecting with said electric media at the outer extremities and separate electrical connections with said collectors.

476,317. System of Testing Electric Circuits; Charles H. Rudd, Chicago, Ill. Application filed Nov. 4, 1889. In an electric light system, an artificial high resistance of invariable amount, said artificial circuit being connected with the different sides of a dynamo-machine while supplying current to a working circuit, said artificial circuit having its resistance apportioned between connecting sockets, in combination with a testing apparatus for determining the neutral point of the artificial circuit.

476,330. Safety Device for Electric Motors; Elihu Thomson, Lynn, Mass. Application filed Oct. 16, 1889. The combination, with a constant potential, of a normally closed branch therein, a translating device, and a protective device included in said branch, the protective device being responsive to abnormal current and being adjusted or constructed to open said branch circuit only after a predetermined time, dependent upon and within the period for which the translating device may carry abnormal current without injury.

476,331. Dynamo-Electric Machine; Elihu Thomson, Lynn, Mass. Application filed Oct. 14, 1889. This invention consists in providing the armature of an alternating current dynamo or induction apparatus with two or more coils or sets of coils, whose positions with respect to the magnetic field are such that the wire of one is subjected to its greatest magnetic influences, while the other coil is not receiving induction, in combination with collectors or rings or connections from the armature wires, whereby two waves of currents may be fed to different circuits outside of the machine from such coils respectively, such waves not coinciding in period, but being displaced one quarter of a wave length.

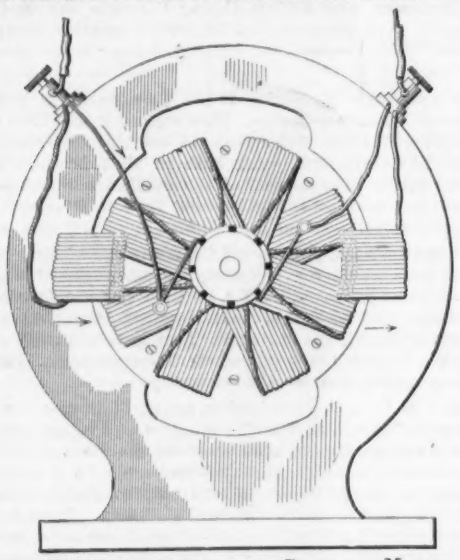
476,334. Base Ball Game; Morris Ullman, Washington, D. C. This invention consists in an annunciator, an indicator operating thereon for varied degrees of movement, a target or strike member, an electrical circuit connecting such indicator with the target or strike member, an electrical circuit connecting the indicator with the target, such varied degrees of movement of the contact serving to adjust the electrical circuit to operate the indicator to the different degrees of movement.

476,346. Alternating Current Motor; Merle J. Wightman, Lynn, Mass. Application filed Nov. 14, 1888. The combination of a source of alternating currents, an armature and a field magnet being both supplied from the said source with alternating currents conveyed through them in a direction to set up repulsion between armature and field at each alternation, and means for keeping out of circuit those portions of the armature between which and the field attraction exists. (See illustration.)

476,347. Electric Motor; David H. Wilson, Chicago, Ill. Application filed Aug. 28, 1891. In an electric motor, the combination of more than one electromagnetic coil wound and connected in series, the adjacent coils wound in a different direction, respectively, and having a common electromagnetic pole, armatures arranged on a common shaft in front of the poles of the series of electromagnets, adjacent ones of such armatures wound in opposite directions, a wire connecting with the wire forming the coil of the electromagnets before such wire enters into the coil and with one of the commutator brushes of the motor and adapted to be attached to one pole of an electrical generator, and a wire connecting with the wire extending from the last one of the series of electromagnetic coils and with the other commutator brush of the motor and adapted to be attached to the other pole of the electrical generator.

476,367. Trolley Support; Spencer C. Crane, Philadelphia, Pa. Application filed March 11, 1892. This is an improved construction in which the trolley support consists of a limited number of exchangeable parts, which may be assembled and taken apart without the use of any tool, and without tightening or loosening bolts or screws, since the several parts are arranged to interlock when assembled and are held in place and prevented from accidental displacement, and this interlocking action is effected by the same spring which tends to constantly elevate the trolley and to hold it in a vertical position.

476,368. Brush Holder for Dynamo-Electric Machines and Motors; Frank B. Daggett, St. Joseph, Mo. Application filed Sept. 8, 1891. An electrical brush holder composed of a triangular solid head of brass or other suitable metal, a cross bolt



No. 476,346.—ALTERNATING CURRENT MOTOR.

connecting the apices of the vertical jaws or sides of the head and covered by a sleeve, a ratchet wheel at one end of said bolt, and a pawl adapted to engage the teeth of the ratchet, a pin passing through the sleeve and bolt midway between the vertical jaws, a swinging plate hung on the bolt, a spiral spring wound around the sleeve with its free ends projecting downward and resting on the side of the swinging plate, and a tongue attached to the bottom of the swinging plate.

476,376. Electrically Controlled Valve; William B. Fleming, Philadelphia, Pa. Application filed Nov. 3, 1888. The combination of the main valve having supply and discharge parts, a piston connected at one side with the main valve, a passage between the supply port of the main valve and the other side of the piston, an auxiliary valve in the passage, an electric circuit and motor for controlling the auxiliary valve, and a circuit breaker arranged in the circuit and connected to the main valve and operated thereby.

476,422. Electric Lighting System; Albert Sechrit Denver, Colo. Application filed December 1, 1891. The combination, with an incandescent lamp circuit of means for controling the same, consisting of a divided battery circuit, two electromagnets, one in each branch of the battery circuit, provided with spring armatures adapted to lock together when brought in contact, one of the armatures being in the lamp circuit and consisting of magnetic material supplemented by a material of higher conductivity, a spring clip, also in the lamp circuit in the path of a projection on the armature, and adapted to make electrical contact with said projection when the two armatures are locked together, and push buttons in each branch circuit, whereby either magnet may be energized according as it may be desired to make or break the lamp circuit.

476,425. Electric Arc Lamp; Edward F. Smith, Cincinnati, O. Application filed Oct. 5, 1891. In an electric arc lamp, the construction whereby the arc is established, consisting of the combination, with the magnet of the series coil and carbon feed rod of such a lamp, of mechanism capable of raising the carbon-feed rod, a lever actuated by this magnet, a rock shaft deriving its motion from the magnet through the medium of the lever, which is rigidly mounted upon the former, and a lateral extension moving with the rock shaft and capable of engaging with and actuating, for the purpose of starting the lamp, the mechanism which raises the feed-rod.

476,426. Electric Generator and Motor; Elmer A. Sperry, Chicago, Ill. Application filed April 3, 1886. In an electric generator or motor, the combination with the field magnets, of the longitudinally adjustable armature, its rotary shaft and commutator, and the contact brushes and devices for simultaneously adjusting the armature in relation to the field magnets and changing the angular position of the brushes on the commutator with reference to the field magnet. (See illustration.)

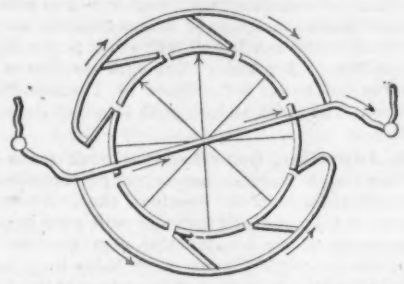
476,437. Electric Locomotive; Thomas E. Adams, Cleveland, O. Application filed May 29, 1890. The combination, with a spring mounted car body and a wheel base, of pulleys in the upper portion of the car body, pulleys on the wheel base, belting for transmitting motion to the pulleys in the upper portion of the car body, and belting connecting the pulleys with the pulleys on the wheel base.

476,463. Electric Chime or Bell; Joseph H. Hunter, Pittsburgh, Pa. Application filed Feb. 29, 1892. The combination, with an electromagnet, of a chime or gong located near the pole of the magnet and movable bodily toward and against the same under the attraction of the magnet. (See illustration.)

476,464. Metallic Circuit Cable; Charles E. Jackson, Boston, Mass. Application filed Nov. 12, 1891. The combination, with an insulated conductor, of two metallic strips wound spirally about the conductor, one of the strips being wound over and upon and to cover space between the turns of the other of said strips, the successive convolutions of each strip being separated.

476,473. Electric Body Wear; Robert S. Mears, Newton, Kan. Application filed Nov. 27, 1891. The combination, with a removable pile, of a cell inclosing the pile, a binding post secured to the top of the cell, and a metallic spring adapted to connect the binding post with the top of the pile and to hold the elements of the pile in position in the inclosing cell.

476,483. Secondary Battery Plate; Edward C. Paramore, Philadelphia, Pa. Application filed Sept. 2, 1890. A secondary or storage battery plate composed of a porous cup, a grid consisting of a strip or sheet cut or divided into leaves and located in the cup, and active material in the latter surrounding the grid or plate.



No. 476,346.—ALTERNATING CURRENT MOTOR.

476,484. Electric Cable; William R. Patterson, Chicago, Ill. Application filed Oct. 29, 1891. In an electric cable, the combination, with a core of insulated conductor or conductors, of an exterior metallic sheath having interior projecting longitudinal ribs in contact with the core.

476,490. System of Testing for Electric Circuits; Charles H. Rudd, Evanston, Ill. Application filed Jan. 19, 1888. A testing circuit, including a telephone and a condenser, the circuit of one side of the condenser being connected directly to ground, and a movable test terminal, in combination with the terminals of a lamp circuit, extended from different sides of the dynamo-electric machine, whereby on connecting the movable terminal with the different extended terminals of the electric light circuit the condition of the electric circuit with respect to insulation may be determined.

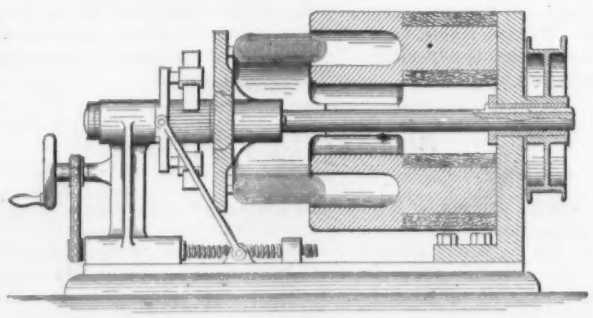
476,492. Circuit for Test Batteries and Cords of Multiple Switchboards; Charles E. Scribner, Chicago, Ill. Application filed June 1, 1885. The combination with telephone lines connected with spring-jack switches on the different boards, of test circuits, one for each telephone line, pairs of cords at the different boards, a cell of battery permanently included in circuit with the different clearing out shutters, the operator's telephone at each board, and switching apparatus whereby the telephone and battery of any pair of cords may be alternately included in and disconnected from the circuit of the cords.

476,493. Electric Arc Lamp; Charles E. Scribner, Chicago, Ill. Application filed Oct. 13, 1891. This improved lamp mechanism consists, essentially, of a centrally pivoted lever whose extremities are adapted to engage with a second lever pivoted at one extremity at different distances, respectively, from its pivotal point; an electromagnet in shunt of the arc, adapted to rotate the centrally pivoted lever in one direction; a spring tending to rotate said lever in the opposite direction, and a second spring acting to press the end-pivoted lever toward the centrally-pivoted lever. The said end-pivoted lever at its free extremity is connected with the clutching mechanism, of any well known form, grasping a rod carrying one of the carbons of the lamp.

476,494. Keyboard System for Metallic Circuits; John A. Seely, New York. Application filed Nov. 15, 1886. In a keyboard system, the combination of calling keys composed each of two levers, a pair of cords having two strands, the two strands being connected to the levers of the calling keys, respectively, contact points connecting with the calling generator, a clearing out annunciator permanently included in a circuit between corresponding levers or springs of the keys, whereby the generator may be looped into the circuit of either of the two telephone lines, while at the same time the clearing out annunciator is excluded from the circuit.

476,501. Incandescent Electric Lamp; Ephraim E. Weaver and Gustavus B. Manypenny, Philadelphia, Pa. Application filed Dec. 5, 1891. Our invention consists of an incandescent electric lamp having a hollow reflector of irregular, square, or elliptical cross section forming the inner wall of the vacuum chamber of the lamp and a filament, the two parts of which are disposed in proximity to the point or ends of the reflector and supported by electrodes sealed to the socket of the lamp, the construction and arrangement of the hollow reflector being such that a supply of air is permitted around about the internal surface, whereby overheating or other damage to the reflecting body of the lamp is prevented.

476,509. Keyboard Circuit for Multiple Switchboards; Oro A. Bell, New York. Application filed Sept. 30, 1891. The spring and contacts which constitute the calling-keys in this improved key are of the usual construction and are mounted upon a block of insulating material. The listening key is preferably mounted on the same block, and consists of a single spring on one side of the block, with its contact-anvil and two springs upon the opposite side of the block, each furnished with a contact anvil and adapted to close together when they are separated from their contact anvils. A connection from the tip of one connecting plug extends through the usual contacts of one calling key to one of the two springs at one side of the block. A connection from the tip of the other plug extends similarly through the contact of the other calling key to the other of the two springs described. The single spring on the opposite side of the block is connected with the sleeves of both plugs. One terminal of the operator's telephone set is connected to the contact anvil of the single spring and the other terminal to the contact terminal of that spring which is connected to the testing plug. The contact anvils of the two springs are connected together through a condenser. Thus these springs perform all the functions of the usual key by simpler means.



No. 476,426.—ELECTRIC GENERATOR AND MOTOR.

476,527. System of Electric Lighting; Thomas A. Edison, Menlo Park, N. J. Application filed Aug. 7, 1882. The combination, with a constant potential main circuit having a difference of potential greater than can be effectively used with an arc lamp, of incandescing electric lamps located in multiple arc branch circuits from such main circuit, arc lamps in other multiple arc branches from the main circuit, and resistances in the separate arc lamp circuits to reduce the difference of potential effective at the electrodes of the arc lamps.

476,528. Incandescent Electric Lamp; Thomas A. Edison, Menlo Park, N. J. Application filed March 16, 1883. In an incandescent electric lamp, two or more separate filamentary conductors connected in multiple arc and a support consisting of a central arm having pins or devices between which the filaments are separately held, whereby they are steadied and maintained at the proper distance apart.

476,529. System of Electrical Distribution; Thomas A. Edison, Menlo Park, N. J. Application filed Oct. 10, 1883. The combination of one or more dynamo-electric machines, two or more metallic conductors extending therefrom, translating devices connected in parallel circuit with such conductors, and means for forming a connection from each of said conductors to the earth without breaking its connection with the machine or machines.

476,530. Incandescent Electric Lamp; Thomas A. Edison, Llewellyn Park, N. J. Application filed June 4, 1887. In an incandescent electric lamp, the combination of contacts in co-operative relation, one being a spring situated in the stem of the lamp, connected with one wire and having an opening through which said wire passes and substantially parallel with the wire, whereby the spring is normally held away from the other contact, which is connected to the other side of the circuit, whereby upon destruction of the wire the spring is allowed to make contact with the other side of the circuit.

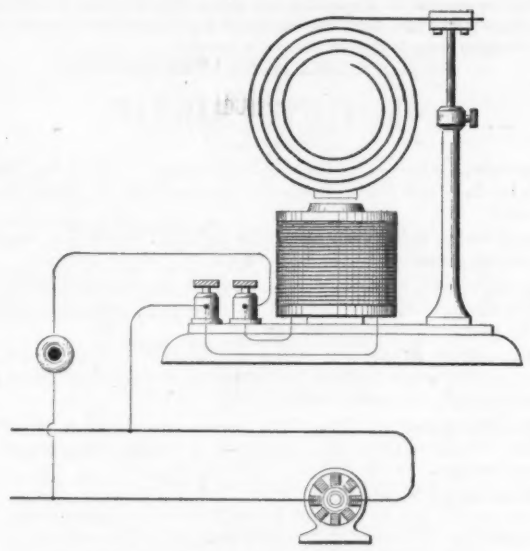
476,531. Electric Lighting System; Thomas A. Edison, Menlo Park, N. J. Application filed April 26, 1881. In a multiple arc system, the combination of three or more derived circuits or branches, each containing an independent translating device, a magnet in the first branch, an armature therefor, normally holding the second branch open, but closing the same when demagnetized, a magnet in the second branch, an armature therefor, which when attracted holds the third branch open, a contact for the armature, connected to the third branch, and a device for holding the armature against said contact when retracted.

476,544. System of Electrical Distribution; Harry Ward Leonard, New York. Application filed Dec. 28, 1891. In a system of series multiple electrical distribution, the combination of main conductors, groups of translating devices in series between them, a compensating conductor connected between the translating devices, an electrical generator connected between the main conductors, and a compensating device of constant difference of potential serving either to receive or produce electrical energy as the excess of load shifts from one side of the compensating conductor to the other, such device being connected between the compensating conductor and one of the main conductors, the compensating conductor being connected with the other main conductor through the translating devices only.

476,570. Fuse Block for Electric Circuits; Elmer A. Sperry, Chicago, Ill. Application filed March 19, 1891. A revoluble block of insulating material having a hub in contact with a conductor, terminals mounted on the block and insulated from each other, and adapted by a rotation of the block to be brought successively into contact with the spring in contact with the terminal, fuse wires connecting the hub to the terminals, and a hand wheel on the shaft of the block adapting it to manual rotation in combination with a supporting base.

476,573. Electrical Valve Controller; John V. Stout, Easton, Pa. Application filed Dec. 22, 1891. The combination of a valve, a toggle joint connected thereto, a fulcrum for said toggle and means for applying power to the toggle, comprising a lever pivoted at the fulcrum, an armature connected to the lever and a magnet adapted to move the armature.

476,582. Microphone; Cæsar Vogt, Posen, Germany. Application filed May 27, 1891. In a microphone, the combination of a diaphragm having two recessed contact blocks insulated from each other with carbon cylinders bridging these contacts, provided with magnetic sleeves, and a magnet or magnets in inductive proximity to the sleeve of magnetic material for maintaining the operative relation between the cylinders and contacts.



No. 476,463.—ELECTRIC CHIME OR BELL.

476,583. Magnetic Telephone; Cæsar Vogt, Posen, Germany. Application filed Sept. 14, 1891. In a double poled telephone, a device for adjusting the outer annular pole with relation to the membrane, composed of a horseshoe steel magnet carrying at the end of one of its branches the bobbin with an iron core as the inner pole, and on the other branch an iron cylinder surrounding the bobbin as the other pole, and of a screw having a head counter sunk into and secured by a washer upon the branch carrying the bobbin, and having a screw threaded shaft engaging in a tapped hole in the other branch of the steel magnet.

476,603. Conduit for Electric Railways; William Bradley, Fort Wayne, Ind. Application filed June 22, 1891. In a conduit for electric railways, the combination of a box or pipe provided with a longitudinal slot, with a slot extending from the roadway or track to or below the bottom of the box or pipe, one side of said slot, the same being adapted to permit the operation of a supporting arm of a contact device, and also adapted to confine within the slot water and other substances which may enter it and conduct such substances outside the box, and a drain placed beneath the slot communicating with it.

476,604. Insulator Bracket; Thomas H. Brady, New Britain, Conn. Application filed April 9, 1892. An insulator bracket consisting of a shank and a hollow head secured to the shank, with an interior space between the shank and head.

476,613. Electric Switch; Charles E. Davis, Chicago, Ill. Application filed Feb. 20, 1891. In an electric switch, the combination of a base, a switchbar having a straight slot therein, catches, a co-operating pin, an arbor provided with pins adapted to engage with the switch bar and to move it parallel to itself out of engagement with the catch with which it is in contact, and a spring for rotating the bar and retracting it to engagement with the succeeding catch.

476,618. Apparatus and System for Compound Telegraphy and Telephony; Francis W. Dunbar, Newark, N. J. Application filed Jan. 25, 1892. A combined simple and inductive resistance consisting of an iron core having its length divided into two wire spaces and a coil formed of a twisted pair of insulated wires would in each of the said wire spaces in the same helical direction, the four inner terminals of the said pairs of wires being electrically united.

476,700. Electric Arc Lamp; Robert H. Thurston, Ithaca, N. Y. Application filed Feb. 27, 1892. An electric lamp having broad flat carbons moving in the same vertical line or in approximately parallel lines, with the carbons arranged in planes intersecting at a small angle for the purpose of preventing the carbons slipping by each other when shaken by the wind or other force.

476,730. Telegraph Instrument; Charles B. Carr, St. Johnsbury, Vt. Application filed Jan. 7, 1892. In a combined telegraph sounder and relay, an arm extending from the sounder to the relay and bearing on each end a fork, and each fork provided with the usual adjusting screws for limiting the play of the armature bars of the respective instruments.

476,733. Galvanic Battery; Martin M. Clark, Chicago, Ill. Application filed Dec. 23, 1888. The combination, with a glass jar, of a wooden ring placed thereon, a lead head resting on the wooden ring, the carbon elements supported by the lead head and being cast therein, the zinc element placed within the carbon elements and centrally suspended from the lead head, a wooden paraffined bushing surrounding the zinc element to insulate the same from the lead, a projection on the lead head and a hardened lead nut placed on the projection.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.